POWER

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Set Your Own Price

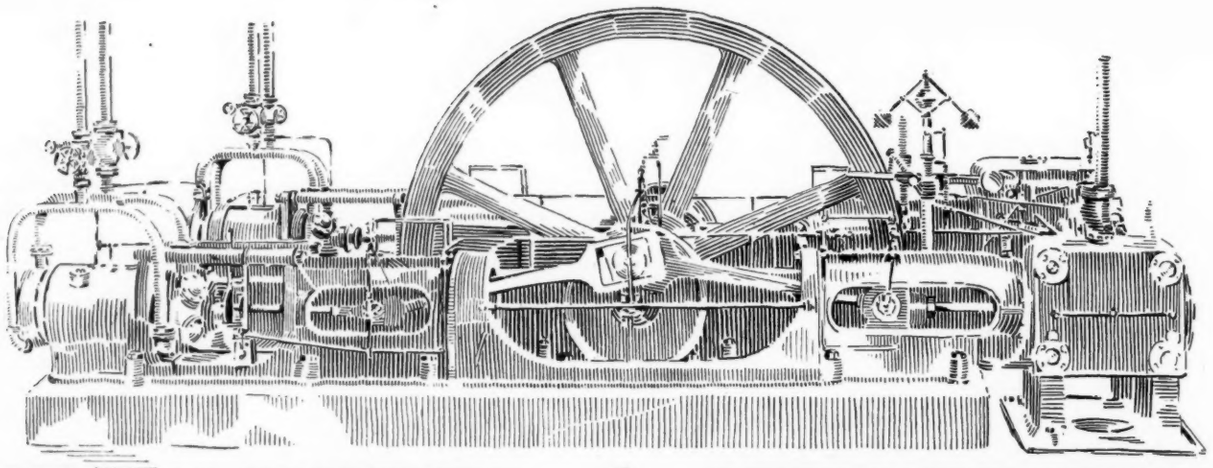
EVERY MAN is exactly what he wishes to be, what he makes himself. Utilization of the time spent in wishing he had the other fellow's luck will pull the man who utilizes that time to the height he desires to attain. Nothing in this world can be achieved without working for it — good hard work. If you are too lazy to do this work, you will not profit by it, but the man who utilizes his time, not only in the plant but portions of his spare hours, will ultimately profit thereby.

Brute strength without brains is always ill paid and a ready mark for the soapbox orator. Brains, even without strength, can accomplish more in a day than brute strength in a year. Brains are in every skull that lives, but it is the use made of those brains that counts. Cultivate them and there is no limit to their progress or the price they can set. Permit them to lie fallow and they are usually worth less than they receive.

One cannot buy knowledge; he must work for it. All the schools and colleges cannot force an education upon you. Attending a school or college does not mean an education. The education is the fruit of the work that you do, not only in the school or the college, but in the shop, in your spare hours, in the way you make your brain work for you. There is your education. No one but yourself can educate you.

You get just as far as you desire to go, you set your own price, by not being ready for the better price, by knowing only barely enough to hold your job. Better jobs do not come by chance; they come by work. Occasionally, someone gets a better job by mistake or by nerve, but that job will not last unless its holder gets so busy that he has no chance to lose.

Contributed by A. D. WILLIAMS



STEAM ENGINES *for* REFRIGERATING PLANTS

By W. H. Motz

THE proper selection and the efficient operation of steam engines for driving ice-making and refrigeration plants are considerations that have great economic importance. In the ultimate analysis it will be noted that it is desired to produce a ton of refrigeration with the least expenditure of money and time. The cost of maintaining the engine room in operation, the cost of fuel that is used for power purposes and the depreciation on the mechanical equipment are important items that enter into the determination of the final cost of a ton of refrigeration.

The proper selection of the prime mover that is best suited to perform the work that is imposed upon it by the refrigeration plant is determined by a large number of factors. In the actual selection of the type of prime mover, due consideration must be given to each factor in order to make satisfactory choice of the type that should be employed.

The most important practical considerations entering into the selection of the prime mover are the following: (1) Reliability; (2) economy of operation; (3) simplicity; (4) flexibility of operation; (5) accessibility; (6) depreciation ; (7) space requirements; (8) character of refrigeration plant.

It is very apparent that the refrigeration plant is a type that must have a dependable and reliable method of driving. The large cold-storage warehouse may be considered as an example. These warehouses are filled with perishable food products generally. It is easy to imagine the great loss that would occur should the refrigeration service fail, due to a breakdown of the prime mover that drives the refrigerating machine.

Factors That Determine Engine Type

The principal factors that affect the economy of the operation of the prime mover are the cost of the fuel, the relative amount that is consumed and the cost of maintaining the engines in operation. The cost of the fuel should be kept as low as possible, but on the other hand, it is generally advisable to secure as good a fuel as is ordinarily obtainable. The fuel consumption should be as nearly constant as possible under varying load conditions. This should be true especially between one-half and full-load capacities.

Ease of operation is an important consideration under all circumstances. The engines should be easy to start and stop. They should be simple in construction so as to be readily understood by the average operating man. If the various parts of the engines are accessible, they are subjected to more thorough inspection, which tends to eliminate breakdowns, and in the case of a mishap the repairing of the damaged parts is facilitated. The parts themselves should be simple in construction, which promotes ease of demounting and reassembling.

The life of any apparatus is an economic consideration. Preference should be given to equipment having the slowest rate of depreciation in order that the disadvantages of deterioration and consequent loss of efficiency may not become too great.

Local Conditions Oftentimes Determine Type of Prime Mover

The particular type of prime mover to be employed is oftentimes determined by the local conditions existing in the plant itself. There may be near the plant a cheap supply of one or more of the fuels that are ordinarily used. Various kinds of fuels may be available. The cost and temperature of the cooling water available is an important item.

The type of steam engine that has been most generally used is the simple non-condensing Corliss, although it has been largely superseded by the compound Corliss. The wide use of the steam engine has been due to several factors, among which the following two are the most important: In the first place, it was not until very recent years that a cheap and dependable power in the form of electricity was available for refrigerating-plant service. Thus, in the past it has been necessary to develop the power for driving the refrigerating machine directly in the plant itself, which condition leads to the use of the steam engine. In the second place, ice-making plants were required to use

distilled water in order to make clean and merchantable ice. To obtain these large quantities of distilled water easily and economically, the exhaust steam from the main driving engine was condensed. This necessitated the use of a steam engine. Of course this condition existed only before the development of the raw-water ice-making system. With this system any type of prime mover may be employed, so that at present electric motors are being used instead of the steam engine as a method of driving the plants in some installations. However, even at present there are many conditions which warrant the installation of steam engines. The type of prime mover that is best suited to a given refrigeration plant is the one that delivers the power at the least cost, taking into consideration all the various charges, such as fuel, labor, supplies, repairs, interest on investment, depreciation, taxes, etc. Thus, in a locality where the cost of electrical energy is not extremely low, it is advisable to consider the steam engine as a probable prime mover. This is especially true of large plants. If the installation is located near a supply of coal, the steam plant will generally be found to be the economical choice. Or again, steam under considerable pressure may be required in other parts of the plant, which would make the use of steam engines more logical than other forms of prime movers. The kind and cost of the water that is available for power purposes have an important bearing upon the subject. Also, the relative capacity of the individual plant is an important consideration. It must be observed that each individual installation is a problem in itself and therefore requires its own special prescription.

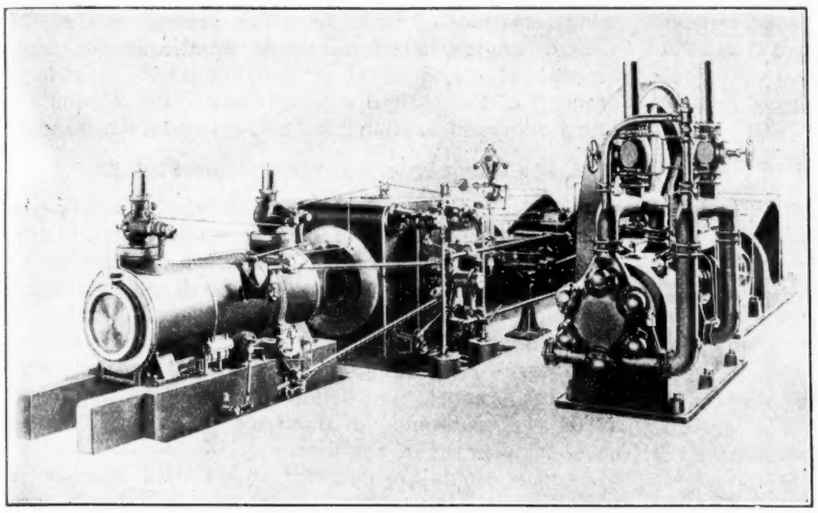


FIG. 1. COMPRESSOR WITH COMPOUND ENGINE

Steam engines that are used for driving refrigerating plants may be classified as slide-valve, Corliss-valve, poppet-valve and unaflow. They may be further divided upon a rotative-speed basis into high-speed and low-speed. They may be classified as non-condensing or condensing and may be further separated on the steam-expansion basis into single- and compound-expansion types.

Steam engines are used in all sizes and nearly all types of plants. The slide-valve engine, of course, is installed only in the small plants. Simple Corliss engines are generally employed on the medium-sized plants, while the compound-condensing Corliss, or the unaflow engine with superheated steam, is frequently used on the larger installations. Condensing unaflow or poppet-valve engines are very economical and are installed in many of the largest plants.

Fig. 1 shows a compressor direct-connected to a compound steam engine having poppet valves on the high-pressure cylinder and Corliss valves on the low-pressure. A unaflow steam engine that is directly connected to a 15 x 30-in. horizontal double-acting ammonia compressor is illustrated by Fig. 2. The unaflow engine affords a very economical method of driving the plant. It may be used on plants having high steam pressure and high steam temperature and can be operated at either high or medium speed. Its chief competitor is the poppet four-valve engine, which is built with the valves set either horizontally or vertically.

Among the factors that affect the economy of operation of steam engines, the following are the most important: The consumption of fuel, the cost of fuel, and the cost of maintaining the engines in operation. The relative expense of maintaining the engines in operation is proportional to their reliability as prime movers. The cost of fuel will vary with the locality. Since under general conditions the magnitude of the load will fluctuate between wide limits, in the selecting of a prime mover for this type of plant important

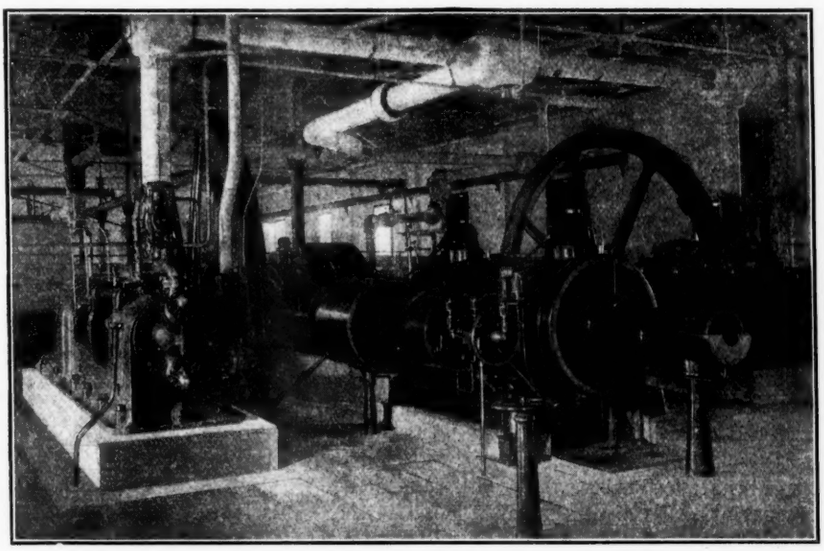


FIG. 2. UNAFLOW ENGINE DIRECT-CONNECTED TO COMPRESSOR

consideration must be given to the efficiency at full-load and at half-load capacity.

Various methods are employed for bettering the performance of steam engines. Among these the following are the most important means: Increasing the boiler pressure, decreasing the back pressure by condensing, use of superheated steam, and compounding. At high

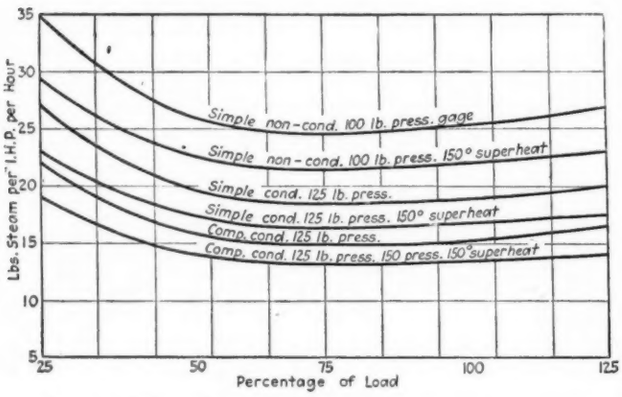

Lbs. Steam per I.H.P. per Hour
Percentage of Load
Simple non-cond. 100 lb. press. gage
Simple non-cond. 100 lb. press. 150° superheat
Simple cond. 125 lb. press.
Simple cond. 125 lb. press. 150° superheat
Comp. cond. 125 lb. press.
Comp. cond. 125 lb. press. 150 press. 150° superheat

FIG. 3. STEAM CONSUMPTION OF CORLISS ENGINES

ratios of expansion high initial pressures have a marked gain in economy. With the ordinary type of steam engine the steam economy increases with the pressure up to a point where it is offset by the increased condensation and leakage losses.

The decrease in steam consumption by operating with 26 in. of vacuum instead of atmospheric exhaust amounts to 15 per cent to 25 per cent, depending on the conditions. The theoretical gain due to the use of superheated steam is small, but practically, the economy is increased greatly. The reduction of the condensation losses in the cylinder is responsible for much of the gain in economy in the actual steam engine. Local conditions favoring the use of superheated steam are high ratios of expansion, high fuel cost and comparatively steady load. The simple engine using superheated steam is as efficient as a compound engine with saturated steam; therefore, superheating may be regarded as a desirable substitute for compounding. The actual gains in economy from compounding are due to high ratios of expansions, decreased cylinder condensation and decreased clearance and leakage losses. Generally speaking, compounding increases economy of steam at full load from 10 to 25 per cent for non-condensing engines and from 15 to 40 per cent for condensing engines.

Fig. 3 shows the effects of these methods of increasing steam economy upon the Corliss-type steam engines of approximately 300 hp. This chart also indicates the variation of steam consumption due to fluctuations of the load on the machines and has been deduced from guarantees of steam consumption by manufacturers of high-grade engines, 26 in. of vacuum being assumed.

Likewise Fig. 4 shows the characteristics of the poppet four-valve steam engine in various arrangements. This type of engine permits the use of higher steam pressures and highly superheated steam. Fig. 5 indicates the performance of the unaflow steam engine. This type is adapted to the use of high pressures and highly superheated steam.

As previously indicated, it is desirable to use a steam engine that has a good efficiency over a large range of load variations. From Fig. 3 will be noted that the Corliss-type engine consumes much more steam as the the load is reduced. Therefore it is desirable to use this type in plants that do not have wide variations of load. From an inspection of Figs. 4 and 5 it will be noticed that the poppet four-valve engines and the unaflow engines operate in an efficient manner under very wide variations of load. This is especially true of the unaflow engine, which consumes practically the same amount of steam at all reasonable loads. The high economy of the unaflow engine is due to the elimination of cylinder condensation losses and exhaust-valve leakage.

Comparative Efficiencies of Plants

In order to show graphically the relative efficiencies of the various methods of driving refrigeration plants, Fig. 6 has been prepared. This shows the number of tons of refrigeration that may be produced by the expenditure of a ton of fuel having a heating value of 12,500 B.t.u. per pound, for various suction pressures. An average condensing pressure of 170 lb. per sq.in. gage was assumed. The boiler-plant efficiency was taken as 60 per cent, and an allowance was made for the usual complement of auxiliaries.

As most plants are operated with Corliss engines, it is well to note the relative efficiency of the simple non-condensing and the compound condensing types. The compound-condensing Corliss-engine plant is very economical in the consumption of steam. On the other hand, a single-cylinder non-condensing unaflow-engine plant with high steam pressures and temperatures will have

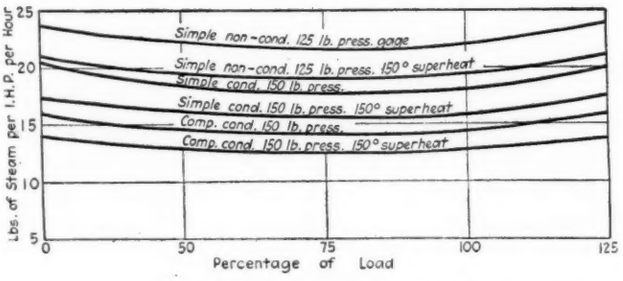

Lbs. of Steam per I.H.P. per Hour
Percentage of Load
Simple non-cond. 125 lb. press. gage
Simple non-cond. 125 lb. press. 150° superheat
Simple cond. 150 lb. press.
Simple cond. 150 lb. press. 150° superheat
Comp. cond. 150 lb. press.
Comp. cond. 150 lb. press. 150° superheat

FIG. 4. STEAM CONSUMPTION OF POPPET-VALVE COUNTERFLOW ENGINES

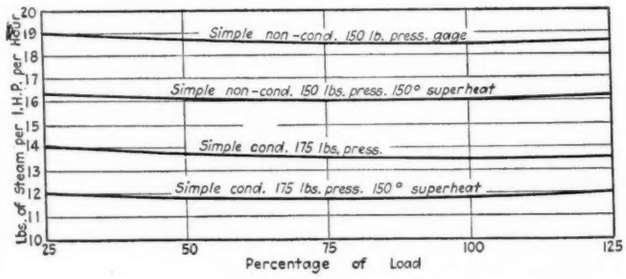

Lbs. of Steam per I.H.P. per Hour
Percentage of Load
Simple non-cond. 150 lb. press. gage
Simple non-cond. 150 lbs. press. 150° superheat
Simple cond. 175 lbs. press.
Simple cond. 175 lbs. press. 150° superheat

FIG. 5. STEAM CONSUMPTION OF UNAFLOW ENGINES

practically the same efficiency. The equipment for the unaflow plant is much simpler and requires, of course, less auxiliary power. A condensing unaflow-engine plant using superheated steam has a higher efficiency than the complex compound-condensing Corliss-engine-driven plant. The use of unaflow and poppet-valve engines with high steam pressures and temperatures is to be advocated for all sizes of plants.

The popularity of the steam engine as a prime mover of refrigeration plants is due, no doubt, to the fact that it is a reliable and dependable means of producing power. It continues to operate under very adverse conditions and will stand a maximum amount of abuse. The compound condensing engine has the disadvantage of being more complex and, therefore, is more difficult for the average operator to handle efficiently.

As compared to plants which are driven by internal-combustion engines or electric motors, the steam-driven plant requires much more space. Compound engines require a maximum amount of space, while simple

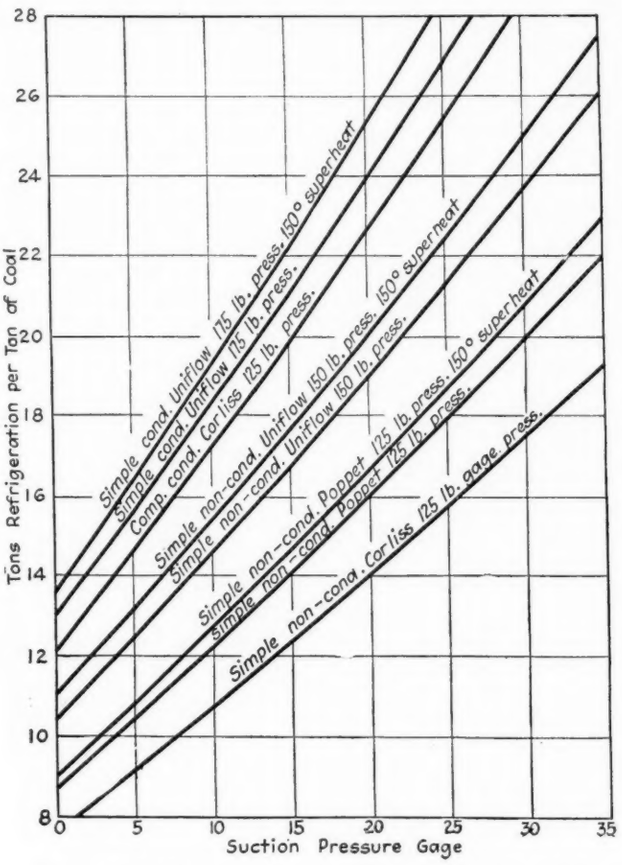


FIG. 6. COMPARATIVE PERFORMANCE OF VARIOUS STEAM ENGINES

single-cylinder engines require a medium amount of space. Space requirements demand important consideration where the cost of land is excessive.

Steam engines have a slower rate of depreciation than the internal-combustion engine and probably will have a useful life somewhat longer than electric motors. The useful life of steam engines will vary from 15 to 25 years, depending, of course, upon the keeping of the equipment in good physical condition by proper maintenance and repairs. The hours of operation have only a slight bearing on the amount of depreciation of the engines. If the engines are kept in proper repair, continuous operation will not cause much greater wear and tear than that produced by intermittent operation. This is due to the fact that engines operating intermittently are subjected to temperature stresses, which will produce more depreciation than the mechanical wear that is occasioned by continuous full-load service.

All in the Day's Work

BY CARL J. JEFFERSON

The cry throughout the land was "Ships! More Ships!" and then, "More Ships!" Marine engineers jumped from the twenty-third place in rank of importance in the engineering world to the top of the heap almost over night. Draftsmen were forced into the naval architects' realm, and a self-sufficient people began to taste the salt tang of a maritime nation.

For a time it looked as if the shipyards of this country would not be able to meet the demand and, in order to forestall any such condition, orders were placed in the Orient for a number of vessels. The specifications for these vessels were very hurriedly drawn up, and some of the equipment which has become a necessity on American boats was omitted, such as refrigerating plants. These were covered by supplementary specifications.

In one particular case in the supplementary specification, there was a clause that the refrigeration piping should be tested out at 500 lb. pressure. It was required that this pressure should be pumped up by the ammonia compressor of the vessel's refrigerating plant.

The refrigerating plant in due time was received at the shipyard, along with a set of instructions in which it was stated, that owing to wartime conditions of manufacture, the compressor had been tested out at only 300 lb. pressure and that this pressure should not be exceeded as the quality of metal in the various bearings could not stand a greater load.

The vessel was practically ready to sail for the States but here was a point that started a discussion and threatened to delay sailing dates until several miles of red tape had been cut away by means of cablegrams. However, the chief who had come aboard to take her away was anxious to get back to the States, and while the builder and insurance brokers argued, he looked the plant over and decided that all parties should be satisfied.

It was a belt-driven two-compressor machine. The plant had an extra large ammonia condenser as the vessel was expected to sail chiefly in tropical waters. He therefore connected the discharge of the one compressor to half of the condenser coils and the outlet of this bank of condensers to the other compressor, using full 1¼-in. pipe. From this second compressor he ran a connection to the remaining condenser coils, which in turn were connected to the rest of the system. He then started up his machine, running up his head pressure to 250 lb. at the first compressor, cooled the air in the first bank of condensers and had a suction pressure of 250 lb. for the second compressor, which he operated at a discharge pressure of 500 lb. with which pressure he tested out his system. When all was found tight, he interchanged the condenser banks and so subjected the entire system to the 500-lb. pressure pumped up by the vessel's own refrigerating machine.

Everybody was satisfied. The machine bearings had not been subjected to a greater pressure than 250 lb. As for the chief—well, that was all in the day's work. It was his job to see that the "black gang" didn't delay sailing dates and that they were ready for the bridge to telegraph, "full speed ahead," at the sailing hour.

The primary horsepower developed in Kansas in 1919 was 232,879, while in 1914 it was 179,146, an increase of 30 per cent.

Protection of Power-Station Equipment

National Electrical Code as Applied to Power-Station Equipment—Various Schemes of Protection and Why Used—Ground Connections—Generators, Storage Batteries, Transformers and Conductor Installations

By EDGAR P. SLACK
Assistant Engineer, Underwriters Laboratories, New York City

CONTINUITY of service is the watchword in the average power station, and within certain economic limits everything must give way to keeping the power on the system without interruption. The National Electrical Code requirements, which deal with the protection of the equipment from becoming a fire hazard, might appear at first to be a secondary consideration. It is evident, however, that just those effects that are likely to cause fire are also likely to interrupt the service, and that the safeguards provided to protect the apparatus likewise tend to insure continuity; so that the Code rules become of prime importance to the power-station designer. They are drawn up in consultation with the industry and combine the views of the insurance expert and the power-station engineer. In a word, they represent simply what is generally regarded as best practice consistent with reasonable cost.

Caution Necessary in Installing Generator

The generator is the source of power, and inasmuch as it has no fuse protection until the switchboard is reached, special precautions are necessary for its installation. The Code requires that generators "must be located in a dry place," so that dampness cannot collect on them, as it would damage the machines and provide leakage paths over which, under extreme conditions, a heavy current could flow. In case of leakage from a live part to the machine frame the frame would be made alive. If the frame were insulated, then an attendant touching it and standing on a cement floor or otherwise grounded at the time would receive a shock. If the frame were grounded, then the first accidental ground occurring on the line might complete a short-circuit, resulting in a heavy flow of current and possibly burning out the generator or the circuit wiring. It is also suggested in the Code that waterproof covers be provided, which may be used to cover generators in cases of emergency.

Electric generators "must never be placed in a room where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flyings of combustible material." The reason for this rule is that sparking at the brushes might be sufficient to set fire to combustible lint or similar flyings or to explode dust or gaseous mixtures.

It is general practice to ground the frames of electric generators to protect the operators against shock, although the Code does not require grounding for machines of 150 volts or less, such voltages not generally being considered dangerous. "Generators must, when operating at more than 150 volts potential and accessible to other than qualified attendants, have their frames grounded" for protection of persons, particularly those unfamiliar with the hazards involved. Where the voltage of the circuit exceeds 150 volts to ground, the frames, if not grounded, shall be permanently and effectively insulated, so as to avoid accidental grounds, which might offer enough resistance to overheat if there were leakage of current. Wooden base frames or floors used to insulate frames must be kept filled to prevent absorption of moisture and must be kept clean and dry, so that the presence of moisture or the accumulation of dirt on the surfaces will not reduce the insulation resistance of the support.

Constant-potential direct-current generators must be protected from excessive current by safety fuses or their equivalent, so that in case of overload or short-circuit the fuses will clear the line and prevent overheating of the machine. Such protection is not required for constant-current machines, whose characteristics are such that they do not deliver an excessive current; nor for alternators, where the inductance of the machine is often sufficient to prevent the flow of an excessive current. The exciter for an alternating-current generator need not be fused, it being considered part of the generator, much like the field circuit of a self-exited direct-current machine. "In alternating-current systems

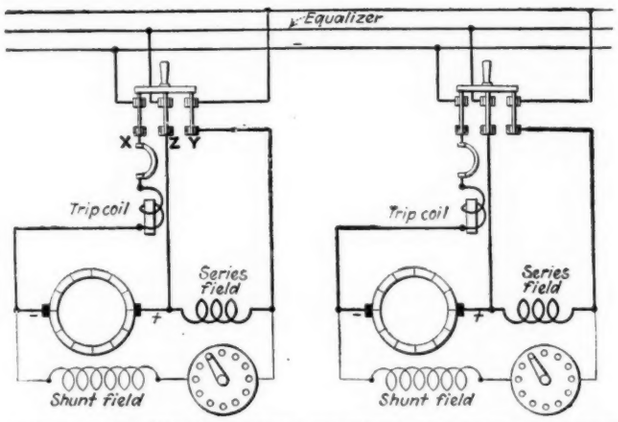


FIG. 1. PROPER LOCATION OF PROTECTIVE DEVICE FOR SINGLE-POLE PROTECTION OF TWO-WIRE GENERATOR

where generator and transformer are intended to operate as a unit for step-up or step-down purposes with both pieces of apparatus located in the same building, no protective device will be required between the generator and transformer." In this case also, the two pieces of equipment form essentially a single device, and fusing of its component parts is not considered necessary.

Form of Protection for Direct-Current Machines

The exact form that the protection for direct-current machines should take in order to satisfy the foregoing rule is explained in the Code for the various types of direct-current generators in common use, as follows:

The object of the cutout is to open the generator circuit in case of excessive current; which requires, first, that the safety device shall be so located and connected that the means for opening it is actuated by the entire

generator current; and second, that the action thereof shall completely open the generator circuit. For two-wire direct-current generators a single-pole safety device will provide the desired protection if properly connected, in which case double-pole protection is not required. In the case of a machine operating alone, either lead would satisfy the requirements, but with machines connected for parallel operation the safety device must be placed in the line to which the equalizer is not connected. Such a case is shown in Fig. 1. Of the two main leads *X* and *Y*, *X* carries the entire generator current while *Y* does not, part of the current returning to the armature through the equalizer *Z*. Also, opening *X* completely opens the generator circuit, while opening *Y* alone would still leave both sides of the armature connected to the system, on account of the equalizer, so that the machine might still deliver current or under certain conditions might become motorized and draw a heavy current from the line. The lead *X* is therefore the proper location for the cutout. Although the Code requires protection in only one generator lead on ungrounded systems, it is good practice to provide a protective device in each lead, as in Fig. 2.

"If a generator not electrically driven supplies a two-wire grounded system, the safety device or devices must be so placed as to disconnect the generator from all conductors of the circuit." Take, for example, a generator *M* direct-connected to a steam engine. Here an accidental ground to the frame at *A*, as indicated in Fig. 2, would find an excellent path to ground through the steam piping, thus resulting in a heavy current flowing as indicated by the arrowheads and operating the cutout at *B*. If the ground at *A* were allowed to remain on the system, it would act as a short-circuit on any other generator *N* being operated in multiple; to prevent this it is required that the other pole of the generator shall also be cleared from the circuit at *C*.

"For two-wire direct-current generators used in conjunction with balancer sets to obtain a neutral for three-wire systems, a protective device must be installed, which in case of excessive unbalancing of voltages will operate to disconnect the three-wire system." The reason for this rule is that excessive unbalancing causes burning out of lamps and overheating of rheostats, heaters and other devices connected to the circuit, with the possibility of fire resulting.

Safety Device to Protect Against Overload

For three-wire direct-current generators compound or shunt wound, a safety device must be placed in each armature lead in order to protect the machine against overload on either side of the system. This device must be so connected as to receive the entire current from the armature; that is, it must be directly in series with the armature so that the machine will be protected regardless of how the current may divide through the equalizer connections. Fuses will not be acceptable, as the blowing of a single fuse would open one side of the system and cause a heavy flow of current in the neutral. For the same reason it is required that the circuit breakers must be so interlocked that no one pole can be opened without simultaneously disconnecting both sides of the armature from the system. The safety device must consist of either a double-pole, double-coil, overload circuit breaker, Fig. 3A, or a four-pole circuit breaker connected in the main and equalizer leads and tripped by means of two overload devices, one in each armature lead, Fig. 3B. Either of these connections insures that the total armature current will be available for actuating the safety device.

The conductors leading from the generators to the switchboards, rheostats or other instruments should be installed with exceptional care because if a short-circuit should occur it would be very severe owing to the absence of any line resistance to limit the current, and particularly because the lines on the generator side of the switchboard have no protective cutouts. One approved method is to install these conductors "exposed to view and supported on approved non-combustible, non-absorptive insulators" so that they can be seen readily at all times and any defects repaired. High-grade insulators are specified to insure against leakage and also to provide a very substantial mechanical support, it being required that the conductors "be kept so rigidly in place that they cannot come in contact." To prevent the conductors from being jammed together where passing through floors or fire walls, "they must be carried through individual openings in non-combustible, non-absorptive insulating tubes or their equivalent and not through a common open space."

Where not run in open work as already described, conductors should be "placed in approved metal conduit, tile or other fireproof ducts." Conductors installed

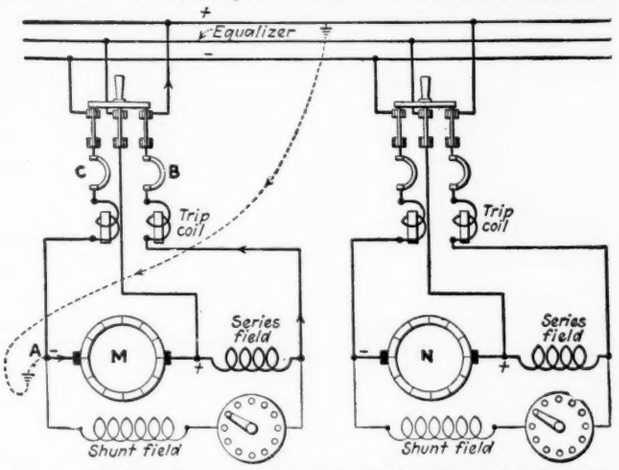


FIG. 2. PROPER LOCATION OF PROTECTIVE DEVICES FOR DOUBLE-POLE PROTECTION OF TWO-WIRE GENERATOR

in conduit or ducts where exposed to moisture must be lead-sheathed to prevent the entrance of moisture into the cable, which might lead to leakage or short-circuits, particularly with varnished cloth insulation, which is often used. The lead sheath must be grounded, and for systems above 600 volts a pothead or its equivalent must be provided at each end to protect the insulation of the conductors where leaving the sheath from moisture and mechanical injury.

Standard Insulation Required

The conductors must have standard insulation "as called for by rules in Class 'C' for similar work, except that where conductors are closely grouped as on switchboards, in wire towers, cableways, etc., the conductors must each have a substantial flameproof outer covering." Rubber insulation and varnished cloth burn readily, and if ignited by a short-circuit or otherwise, would add fuel to the fire and constitute a serious hazard unless protected as described. Most manufacturers furnish wire having a braided covering impregnated with a fireproof paint for this class of service. The flameproof covering, having less insulating value than the rubber insulation beneath it, "must be stripped back on

all conductors a sufficient distance from the terminals to give the necessary insulation for the voltage of the circuit on which the conductor is used." In all other respects the conductors "must be installed with the same precautions as required by rules in Class 'C' for wires carrying a current of the same value and potential."

The switchboard to which the conductors are carried generally has a large amount of exposed live metal, carries arc-producing switches, fuses and circuit breakers, often supports heat-producing rheostats, and is connected to a large mass of wiring. These features combine to make the switchboard a real hazard, requiring special protection. The board must be made of non-combustible material, such as slate or marble, so that it cannot burn, and "must be placed so as to reduce to a minimum the danger of communicating fire to adjacent combustible material." Ample space should be left all around the board to give workmen room to make changes and repairs with safety and also to allow effective fire fighting in an emergency. For this reason "switchboards must not be built up to the ceiling, a space of three feet being left, if possible, between the ceiling and the board," and also, if the wiring is on the back of the board, as is usually the case, "there must be a clear space of at least eighteen inches between the wall and the apparatus on the board, and even if the wiring is entirely on the face, it is much better to have the board set out from the wall." Switchboards "must be kept free from moisture" to prevent leakage of current between parts of opposite polarity mounted side by side on the board, particularly with a comparatively absorptive material such as slate. "The space back of the board must be kept clear of rubbish and must not be used for storage."

The number of fires that occur through carelessness and "poor housekeeping" is appalling. The accumulation of litter behind the board or the use of this space for hanging clothing should not be countenanced. Instrument and pilot-light circuits on switchboards should be wired with not less than No. 14 B. & S. gage wire, for proper mechanical strength, and should be protected by approved fuses, preferably of the N. E. Code standard inclosed type.

Oil Circuit Breakers and Switches fo High-Potential Circuits

Oil circuit breakers and switches, in which the switching parts are immersed in a tank of oil, are commonly used for high-potential circuits. On account of the presence of the oil, which is inflammable and thus introduces an additional hazard, the Code requires that such devices "must, wherever practicable, be isolated from other switches and electrical apparatus. On circuits of over 7,500 volts they must be of the remote-control type and be inclosed in separate fireproof cells or compartments." This construction keeps the high voltage away from the board and thus serves to protect the operator, and also localizes a fire, if one should occur, to a single fireproof compartment.

"Each constant-potential circuit entering or leaving a supply station, except grounded-rail return conductors of railway power plants or grounded neutral conductors of three-wire systems, must be protected from excessive current by an approved automatic overload circuit breaker or by an equivalent device of approved design," so that if an excessive current should flow, as in the case of a ground, the breaker would operate and protect the feeder from further damage. In the case of grounded return for railway work, the line and generator both being grounded, a breaker would be shunted out if provided; and in three-wire systems the neutral must be maintained to preserve a balance, so that in these cases the cutout in the grounded conductor is omitted. "Such protective devices must be located as near as practicable to point where conductors enter or leave the building," so that where the circuit is connected to some other source of power the outside source cannot continue to supply excessive current to any apparatus in the station in case of trouble. As a matter of economy a simplified construction is permitted where this condition does not hold, the Code permitting the protective devices to be placed on the supply side of transformers and similar devices for outgoing circuits not connected to other sources of power.

Location of Lightning Arresters

Each wire of every overhead circuit connected with the station must be connected with a lightning arrester

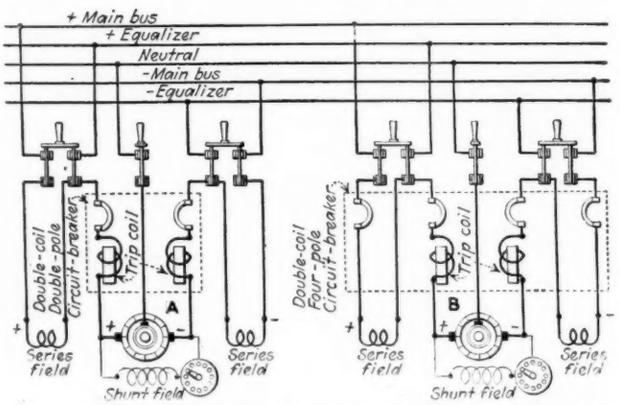


FIG. 3. ACCEPTABLE METHODS FOR PROTECTING THREE-WIRE GENERATORS

located as near as practicable to the point where the wires enter the building. For ease of inspection and maintenance the Code requires that lightning arresters "must be located in readily accessible places." The arresters must be located away from combustible materials, "well isolated from all other equipment, and if of the oil-immersed type must be located outside or in a fireproof room or compartment on the premises." The impedance offered to a high-frequency surge by even a few turns in the circuit is very considerable, and in order not to interfere with the ready discharge to ground it is required that "in all cases, kinks, coils and sharp bends in the wires between the arresters and the outdoor lines must be avoided as far as possible," and for the same reason "the ground conductor must be as short and straight as practicable. Each distribution system originating in a station under attendance must be provided with a reliable ground detector unless permanently grounded."

"When current for light and power is taken from primary or secondary batteries, the same general regulations must be observed as apply to similar apparatus fed from generators developing the same difference of potential." Storage batteries, often floated on the line in power stations, have a very low internal resistance, and thus are capable of delivering a tremendously heavy current in case of short-circuit, so that it is especially important that all precautions be applied in the installation of circuits and devices. The presence of acid

fumes makes wood unreliable as an insulator, hence it is required that all storage batteries "must be mounted on non-absorptive non-combustible insulators, such as glass or thoroughly vitrified and glazed porcelain." Glass battery jars are usually considered as meeting this requirement.

It is required that for power stations transformers shall be so placed that, in case of failure, fire and smoke from the burning out of the coils or the boiling over of the oil can do no harm. "For oil-cooled transformers used in stepping voltage up or down before distribution, this will usually require a separate fireproof building, room or compartment cut off from the plant proper, provided with not less than 6-in. non-combustible sill at doorway and with floor drained to some convenient point outside the building." This construction is designed to prevent the entrance of oil into the building proper and to provide means for draining it to an outside point where it can do no harm. "Transformers of the air-cooled type should be isolated from all other equipment" so that in event of a burnout other apparatus will not be endangered thereby, "and if of air-blast type should be supplied with air through fireproof ducts" to prevent the ducts from taking fire in case of flames being drawn into them from a burnout. Most transformers operate at high potentials, making it especially necessary that their tanks should be grounded to protect the station attendants against the possibility of a dangerous shock in case of accidental breakdown of the insulation.

Boiler-Room Instruments as an Aid to Firemen

By Henry Kelsey

The use of CO_2 recorders, draft gages and pyrometers as a means of checking the efficiency of boiler furnaces and their operatives has for years been recognized by leading engineers as necessary in any plant. But the greatest value of these instruments, from a practical operating standpoint, lies in their ability to guide the firemen to the successful performance of their duty.

In most plants the purchase of coal is left to an executive in the front office, or if the chief engineer is given this responsibility, there is usually a limit placed on how high a price he might pay per ton, thus preventing him from going into the open market and buying only the coal he would like to use, regardless of price. In either case, and especially with present market conditions, the chances are extremely remote that the coal bunkers back of the boilers, will ever see the same kind, size or grade of coal more than a few days in succession.

With this condition confronting almost every boiler-room force, especially in the Middle West, it is little wonder that considerable loss is caused in fuel, time and steam output in plants that have not proper apparatus, by trying through actual, costly experiment to determine the best way to burn "today's" particular fuel.

No two coals differing in volatile, moisture or ash content or differing in size, should be fired alike. "Today's" coal might produce wonderful results in a natural-draft plant, with a 6-in. fuel bed, and 0.25 in. of water draft over the fire. Tomorrow, with coal from another mine or seam or of a different size in the bunkers, the foregoing conditions would give unsatisfactory results. The load would be hard to carry, the fuel bed would give off smoky, yellow flames and if the stack were observed, one would suspect tar was used for fuel instead of coal. At this time, in plants without apparatus, comes the hard, costly guesswork. By experimental means only, in changing the fuel bed thickness and by the draft and noting the effect on the steam gage, can the man in charge finally determine the best method to use in getting the heat out of the coal and into the boiler water, and there is no telling at what cost to efficiency this is being done.

Contrast the foregoing illustration with the procedure in a plant that is equipped with apparatus that eliminates all guess-work on the part of the boiler-room force. The man in charge sees that the methods used yesterday do not produce results with the coal used today, so he proceeds to change the position of the damper slightly and then notes the effect as shown on the CO_2 recorder, draft gage and pyrometer. As these instruments tell their story almost instantly, he soon knows whether the change was for better or for worse. If worse, another change in either the draft or fuel bed is made, each change being governed by the CO_2 content of the uptake gases as read on the recorder chart. When the CO_2 percentage that good practice has proved best has been attained, an eye being kept on the pyrometer in the meantime, he states the routine for the day, giving the draft and the fuel-bed thickness to be maintained.

In forced-draft stoker-fired plants the instruments have proved most valuable. The draft over the fuel bed, as near balanced as possible, is, of course, uniform from day to day with almost any kind of coal; but the blast under the fuel, stoker speed and last-pass draft are factors that vary with different coals. These variables can be made constants in less than one-half hour in plants properly equipped with checking apparatus, even if a radically different coal might be fed to the stokers.

After the best relation of draft to the fuel bed is found—that is, that pressure difference that will carry the load and produce the highest percentage of CO_2 without CO—then any changes during the day in either stack temperature or CO_2 can almost always be traced to some physical defect in the boiler setting or baffles.

In a certain plant recently, someone had carelessly failed to close a clean-out door at the side of one of the boiler settings. It was only by noting the low reading that the CO_2 recorder made, that this open door was discovered in less than five minutes after the man had left the boiler. Without the apparatus, the loss due to excess air rushing in through that opening might have continued for an hour or more, in the meantime more coal being burned.

When combustion testing apparatus is installed, it is of the utmost importance to emphasize to the boiler-room force that the instruments are there to assist them and make their work easier, just as much as they are bought to give the management an accurate record of how much of the available heat in the fuel they buy, is offered to the boiler to absorb.

Legislation that would restore without reservation those areas withdrawn by the President as power site reserves, which in fact have little or no actual value for power purposes, has been recommended by the Federal Power Commission. Some 2,500,000 acres were withdrawn by the President under the Act of June 25, 1910. Some 325,000 acres have been withdrawn under the Federal Power Act.

Burning More Coal To Increase Boiler Capacity

By THOMAS WILSON

YEARS AGO, in the days of low steam pressures and relatively small grate area, boilers were operated up to rating, so that at the maximum load they were supposed to carry the evaporation from and at 212 deg. did not much exceed 2 lb. of water per square foot of heating surface per hour. Gradually it was found that boilers could be operated safely at higher ratings and that 10 sq.ft. of surface would evaporate 34.5 lb. of water per hour (the measure of what was known as the boiler horsepower) with no apparent injury to the boiler. So the surface per so-called horsepower was reduced to 10 sq.ft., equivalent to an evaporation of 3.45 lb. of water per unit of surface, and the boilers were operated up to rating as before.

As years went by it became the practice, particularly in the larger stations, to operate the boilers up to 200 per cent of rating, then at three times their normal capacity, and as the relative proportion of the stoker was increased operation at ratings up to 400 per cent of normal is no longer considered phenomenal. Thus the old standard of 10 sq.ft. of steam-making surface per boiler horsepower, and in fact the term horsepower as applied to boilers at all, has become obsolete and has been discarded recently by the engineering fraternity. Reference is made rather to the square feet of heating surface a boiler contains or to the amount of water it can evaporate per hour. Throughout this general trend toward higher capacities no particular difficulty was encountered so far as the boiler was concerned. The boiler was always able to absorb the heat supplied to it with no apparent injury provided ordinary precautions were observed. Owing to the fact that the average rate of evaporation has increased from 2 lb. per sq.ft. in the early days to the present 8 to 12 lb. per unit of surface pure water is becoming of greater importance from the viewpoint of both economy and safety. In fact, in some of the later plants an evaporative system for the makeup water is coming into favor.

More intensive use of the heating surface in a boiler is the prevailing trend in power-plant practice. To increase capacity in order to secure a greater return on the investment, the chief problem has been with the stoker. The stoker speed is determined by a definite time element for burning established by the size and quality of the coal. Boiler capacities have been increased by enlarging the grate area, by adding to the length or the width of the stoker and more recently by the use of forced-draft stokers. Improved economy has been effected also by conserving the waste heat in the flue gases and by reducing to a minimum air leakage into the setting. The article deals principally with the practice of the commonwealth Edison Co. in burning midwest coals on chain-grate stokers.

In addition to this more active use of the steam-making surface steam pressures have been increased, and to keep pace with the growth in prime movers the average size of boiler has been greatly enlarged. Likewise the boiler capacity per square foot of floor area is greater, owing to the factors mentioned and to increasing depth of tube banks.

The more serious problems have been with the stoker, and the prevailing question of the day is how to burn more coal under a boiler to increase its average rate of steaming and to utilize to the full the investment in equipment and building. Higher prices all along the line, more expensive material, wages exceeding former rates and the greater cost of coal have given impetus to the movement toward higher capacities and, to justify these capacities, the development of equipment to conserve the additional heat carried in the flue gases.

As an illustration take a boiler operating at normal with a flue-gas temperature of 450 deg. F. Push this same boiler to 250 per cent of rating, and the flue-gas temperature will range from 600 to 650 deg. What is gained in capacity is lost up the stack, and the game may not be worth the candle. Add to this boiler an economizer, reducing the flue temperature to, say, 300 deg., and the higher rating is justified. The flue-gas temperature is less than for normal operation by 150 deg., and although the efficiency of the stoker may be lower under forced conditions the gain in capacity will more than offset the loss by reducing the initial investment. Reversing the viewpoint, the boiler must be operated at high rating to pay for the economizer. Progressing in the same direction, the next step is the introduction of an air preheater after the economizer, which, in heating the air for the boiler furnace, will further reduce the temperature of the flue gases and conserve for good purposes the waste heat that would otherwise escape to the atmosphere. Thus, instead of operating a boiler at normal with a flue-gas temperature of 450 deg., the use of an economizer and air preheater, reducing the flue temperature to the vicinity of 200 deg. F., will make economical a rating maintained at, say, 300 per cent or greater if the fuel and operating conditions will permit. The over-all efficiency of the installation is somewhat improved, and one boiler is doing the work formerly requiring three for the cost of the heat-saving apparatus.

The tendency, then, is toward higher capacities. The recent drop in the price of coal will not retard this movement. To make it profitable the refinements mentioned are a necessity, the savings they will effect depending largely upon the cost of coal.

An evaporation of 8 lb. of water per square foot of steam-making surface has been maintained in practice; for peaks of short duration an evaporation of 12 lb. has been attained, and there is no reason why the boiler should not absorb heat at a higher rate. It is the

stoker and furnace that are the limiting factors, and the problem is how to burn more coal efficiently.

The experience of the Commonwealth Edison Co., of Chicago, along these lines is interesting, as it portrays the general development that has taken place in chain-grate stokers. Bituminous coal from the fields of Illinois has been the fuel used. Years ago at the Fisk Street Station the standard unit was a 5,000-sq.ft. boiler equipped with 72 sq.ft. of active grate area in a chain-grate stoker, giving a ratio of steam-making surface to grate area of almost 70 to 1. As would be expected from present-day knowledge, it was soon found that there was entirely too little stoker. Later, as boilers of the same size were added to the station, 90 sq.ft. of grate area was provided, reducing the ratio to 55 to 1. At the Quarry Street Station 105 sq.ft. of active stoker was placed under the same boiler, the ratio in this case being 47.6 to 1, and at the Northwest Station the first steam-generating units installed consisted of 5,600-sq.ft. boilers and chain-grate stokers having an area of 115 sq.ft. The ratio of steam-making surface to grate area was practically the same as at Quarry Street, the exact figure being 48.7 to 1.

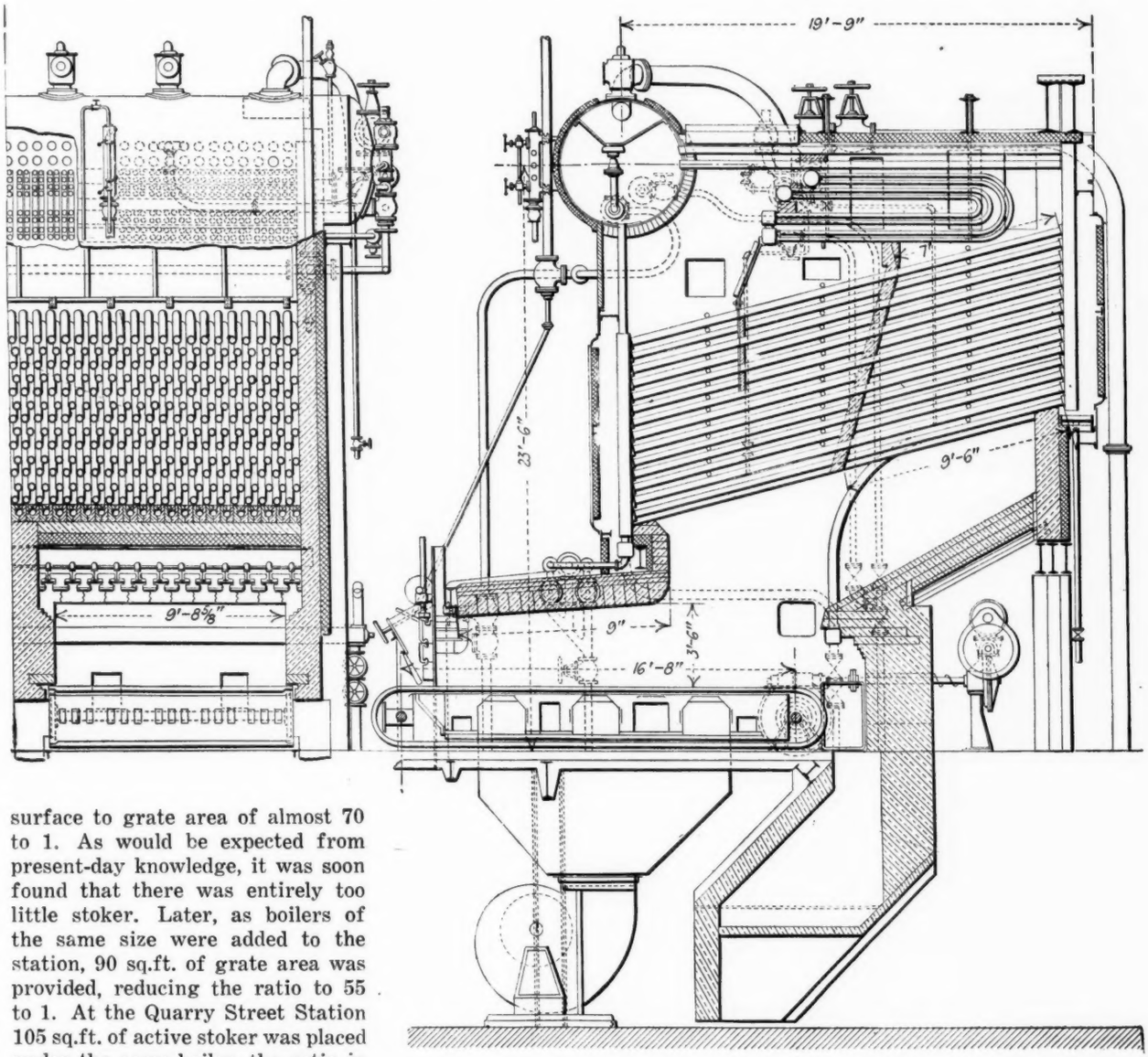


FIG. 1. FORCED-DRAFT STOKERS UNDER 12,260-SQUARE FOOT BOILERS

Increasing need for operation at higher capacities again called for stoker development. It was recognized that the amount of evaporation depended primarily on the quantity of coal that could be burned. Continued operation with chain grates had proved that the limit with natural or induced draft had been reached when about 43 lb. of coal was being burned per square foot of grate per hour. For higher rates with Illinois coal the difficulty was to hold the ignition. Speeding up the stoker above a certain rate merely dumped unburned coal into the ashpit. A definite time element entered into the problem. To burn coal of a certain size it must remain in the fire a specific length of time or combustible will go to the ashpit. The finer the coal the faster it will burn, and the coarser, the longer the time needed for proper combustion. Consequently it is the time element determined by the size and the quality of the coal that limits the speed of the stoker.

To burn more coal, then, continues to be a problem of adding to the grate area. One solution is to increase the width. Furnace construction, particularly before the day of the flat arch, imposed limitations, but recently some important steps have been taken in this direction. More flexibility is secured by adding to the length of the stoker. At the same stoker speed more coal can be burned by thickening the fuel bed, as with

the longer stoker the time in the furnace has been increased. With the same thickness of fire the stoker can be speeded up and more coal will be burned. There is considerable leeway for adjustment between these two factors to suit any particular coal and still keep within the definite time element established by its size and quality.

As turbines became larger there was need for boilers of greater capacity, so that the next step at the Fisk Street Station was units containing 12,260 sq.ft. of steam-making surface, equipped with double stokers independently operated. Each stoker was 10 ft. wide, but the length was increased to the abnormal figure at that time of 13.5 ft., giving a total area of 270 sq.ft., which to the steam-making surface bears a ratio of 1 to 45. This installation is shown in Fig. 1. The next stage of development is represented by eight boiler units recently installed, each having 14,500 sq.ft. of surface and with double stokers having an aggregate area of 330 sq.ft. The stokers are thus proportionately larger, and in this case bear a ratio to the steam-making surface of 1 to 44. The width of the stoker has been reduced, but the length has been increased to 17.5 ft. Except for its great size the stoker is standard. In fact, all the way through the progress reviewed, the general design of the stoker has remained much the same. There have been no radical changes in the links or the driving mechanism, although in some of the later stokers an ingenious application has been added to facilitate changes in the speed of the stoker from 2 to 11 in. per min. However, the various parts, such as the frame, rolls, link rods, etc., have been greatly strengthened and are naturally much heavier than in the shorter stokers.

The arrangement of the unit will be evident from the accompanying sectional view, Fig. 2, through the setting. The stoker is set under the low end of a cross-drum boiler 42 tubes wide and 14 tubes high, built to evaporate 100,000 lb. of water per hour, or nearly 7 lb. per square foot of surface. The setting is of the reversed type commonly used by the Commonwealth company. The gases take the path indicated and are drawn through an economizer over the boiler by an induced-draft fan discharging to the smoke flue. An innovation is a drop leg under the tube header, placing the first row of tubes 21 in., center to center, below the second row. The idea is to take advantage of the radiant heat, to facilitate the removal of slag and soot which invariably form on the first tubes, and to make easy replacements in the horizontal baffle.

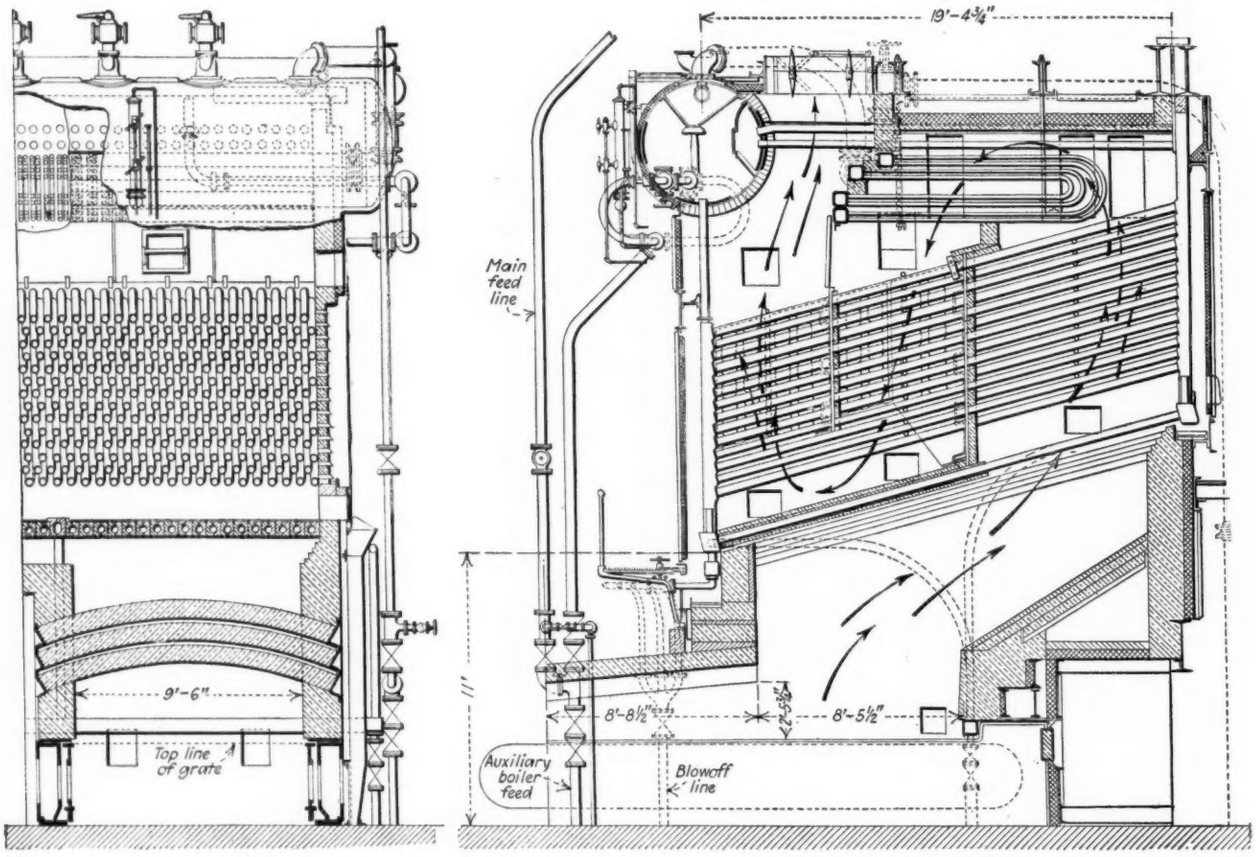


FIG. 2. TYPE OF SETTING FOR CHAIN-GRATE STOKERS 17.5 FEET LONG

As the bottom of the mud drum below the front tube header is 11 ft. above the floor line and the slope of the boiler is upward and away from the stoker, there is large combustion space. The furnace volume is 3,105 cu.ft., which reduces to 9.4 cu.ft. per square foot of grate area. As the rate of burning is about 43 lb. of coal per hour per square foot of grate, the volume given reduces to 0.2 cu.ft. per pound of coal burned per hour. The rear wall of the setting has been drawn in to meet the bridge wall, and at this point there are inspection doors through which the fuel bed at the rear of the stoker may be inspected

or sliced when necessary. Louver dampers under the grate have been provided front and back, but as the boilers are operated continuously at high rating, there has been no occasion to use them.

Although the driving mechanism of the stoker has been designed for adjustment of speed from 2 to 11 in. per min., in operation the maximum grate speed has not exceeded 5 and the average speed has been about 4 in. per min. It has been much the same on the older and smaller stokers, and this also applies to the rate of burning. On either the small or the large stokers the apparent limit of 43 lb. of coal per square foot of grate can be reached but not exceeded with this type.

Utilizing the More Efficient Units

In the station the plan of operation is to utilize to the full the larger and more efficient boiler units. During the peak loads the smaller boilers are brought into service. When operating at the full steaming capacity of 100,000 lb. per hour, the large units have shown an over-all efficiency of 80 per cent and above. Reducing air leakage to a minimum has made such economy possible. The reduction of air leakage was vital, as a fuel bed 10 in. thick, of 1¼-in. screenings containing more duff than in pre-war days, called for an uptake draft of 2¼ in. and 0.6 in. over the fire.

It was found that steel casings were no guarantee against all leakage, as they do not necessarily protect the joints between the brickwork and the boiler or the openings around the arches and the stokers. By means of orsat analyses of the samples taken minute search was made through the setting for leaks indicated by streaks of air. Workers then went inside of the steel casing and closed up the many small leaks located, made more permanent and effective joints by the use of tile fitted to the place for which it was intended, stopped as much as possible leakage around the stoker and the arch and made sure that the baffles were tight. This leakage has been reduced to 15 per cent or less, which is generally considered the practical minimum for a chain grate.

At the extreme end of the economizer or the inlet to the induced-draft fan the temperature of the gases is less than 300 deg. F., the CO_2 at the same point has increased from 7 to 10.5 per cent, and, as stated, exceptionally high efficiencies have been obtained. This economy with Illinois screenings is close to that theoretically possible, so that there is small margin for improvement. With the present layout using induced draft the possibilities for still further increasing capacities are limited.

Increasing the Rate of Burning

There still remained, however, one other factor, in addition to enlarging the grate area and speeding up the stoker, that would increase the rate of burning. If more air could be supplied than was available with either natural or induced draft more coal could be burned, and not only that but coal of an inferior quality that was unusable before. For coals of the Middle West the forced-draft chain grate offered a solution. On two different stokers of this general type long series of tests were conducted, with the result that installations of these stokers are now giving excellent satisfaction at the Fisk Street Station.

To get more steaming capacity the natural-draft stokers under the 12,260-sq.ft. boilers were removed, and to take their place two forced-draft chain grates were installed, each having an active area of 139 sq.ft., thus giving 278 sq.ft. of grate per boiler, as compared to 270 sq.ft. for the natural-draft stokers that were discarded.

Also, under one of the 14,400-sq.ft. boilers two forced-draft stokers 17.5 ft. long and having a total area of 330 sq.ft., the same area as contained in the natural-draft installations, are being given a thorough test. In either case the average capacity has been increased 40 per cent, and the flexible air control makes it possible to burn the inferior coals, all the way down to coke braize that the natural-draft stokers would not take, and still maintain capacity.

As coal-burning devices the new stokers are exceptional, but no attempt is made to push them to the maximum limit as, in existing settings, pressure drop and gas velocities in passages proportioned for natural-draft operation must be considered. As the forced-draft stokers have the same area as the natural-draft equipment replaced, forcing them would crowd the gas passages and result in rapid deterioration of the furnace. The endeavor is to operate the boilers at the point where the efficiency line, taking into account operating and maintenance costs, crosses the investment line.

Average Rate of Burning Maintained with Illinois Screenings

On the basis already outlined an average rate of burning with the forced-draft stokers is maintained at 50 lb. per square foot of grate per hour as compared to, say, 38 lb. for the natural-draft stokers, the coal being an average grade of Illinois screenings. On test a rate of 56 lb. per square foot of grate has been maintained for seven hours, and at times the combustion exceeded 60 lb., with the possibility of going higher if desired. For the foregoing reasons, however, normal operation has been limited to the rate given. The boilers are in continuous service 24 hours a day, to carry as much of the load as possible, the smaller and less efficient units being called upon to help carry the peak.

Thus the boilers are maintained under forced-draft operation, although on trial they have given very satisfactory results on natural draft. In a station with a large number of boilers this method of operation is possible. In a comparatively small station the plan would be to operate normally on natural draft and carry the peaks on forced draft. Experience at the Fisk Street Station shows that such procedure would be entirely feasible, giving a wider range as to fuels burned and reducing the boiler capacity it would otherwise be necessary to install.

There are, of course, other types of stoker, such as the underfeed, which has given excellent results with coals of the Middle West. Progress is being made in the burning of pulverized fuel under boilers, and for large plants of the character under discussion there are possibilities in the low-temperature distillation of coal to recover the byproducts before using the residue for fuel.

These methods of treating fuel are for the future, as they need development before they can be accepted as standard. It will be interesting to observe the next link in the long chain of progress, as it should indicate the general direction in which development is to be expected.

Loss of Compression in Diesel Engines—Causes and Remedies

By LOUIS R. FORD

COMPRESSION of atmospheric air or a mixture of air and fuel is a very important phase in the cycle of any internal-combustion engine. In the Diesel engine this air compression is carried to a very much higher pressure than is the case with those types of engines that compress a mixture of air and fuel, and this higher pressure is correspondingly more difficult to maintain and more susceptible to the effect of worn parts or bad adjustment than is the pressure in the low-compression engine. Correct adjustment and maintenance of compression are essential to satisfactory performance of any Diesel engine, whether for stationary or for marine service. To insure prompt ignition and efficient combustion of the fuel, the compression in a Diesel engine should never be less than 450 lb., and some builders carry it as high as 500 lb. It is possible to operate with a much lower compression pressure, and in some cases it is allowed to fall as low as 350 lb., but here the economy of the engine is poor and its operation will be otherwise unsatisfactory. According to natural laws the pressure at the end of compression is a function of the volume and temperature; that is, the pressure is determined by the volume and temperature of the air in the cylinder at the beginning of compression and its volume at the end of compression, or $P_1V_1^n = P_2V_2^n$ and $PV = MRT$. The temperature of the incoming air may vary, depending on the location of the station and the season of the year, and this temperature is raised somewhat by contact with the hot metal of the heads and inlet valves. However, for figuring the compression the designer generally assumes a constant suction air temperature of 60 deg. F. and a value of 1.4 for n. To obtain any desired compression pressure, then, involves computing the linear clearance between piston and head necessary to produce the volume corresponding to this desired pressure. In a completed engine this linear clearance, which determines the pressure at the end of compression, can be changed by any of the following methods: (1) Changing the length of the connecting rod; (2) changing the length of the piston rod; (3) altering the position of the piston pin in a trunk-piston engine; (4) changing the thickness of the gasket under the cylinder head; (5) adding plates on top of the piston; (6) changing the thickness of the liners under the foot of the connecting rod. This last is the only practicable method that may be used after the engine has been installed, and it is for this reason that the engine builder makes the total connecting-rod length include $\frac{3}{8}$ in. to $\frac{1}{4}$ in. thickness of metal shims between the foot of the rod and the top of the crankpin box.

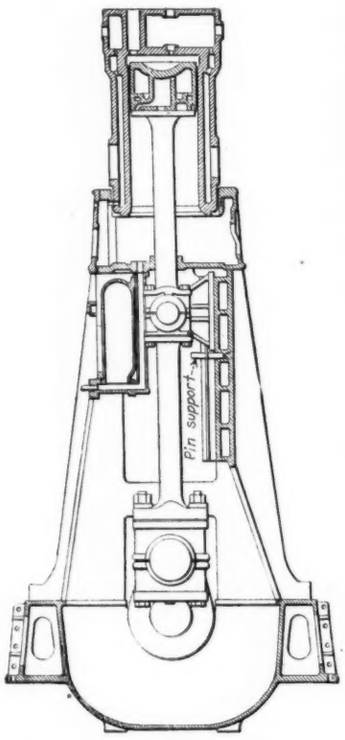


FIG. 1. SUPPORT FOR PISTON AND ROD

Having the necessary engine dimensions, it is a simple matter to calculate what the compression should be if conditions are right; but in order to determine whether the compression actually obtained corresponds with this calculated compression, it must be measured by some pressure-measuring instrument. The indicator is universally used for this purpose because it furnishes a graphic record. One of the first things done after the engine is erected is to take compression cards from each cylinder before any operation under power is attempted; the right-angle card is better than the ordinary diagram. If the engine is arranged so that it may be operated with starting air on one or more of the cylinders, the compression cards may be taken on the remaining cylinders while the starting air is used to turn the engine over. Where the starting air must be used on all cylinders at once, the engine may be started, and while it is operated on fuel, one cylinder at a time may be cut out and a compression card taken. When this is done, the spray air, as well as the fuel, must be cut off from the cylinder in which the compression is being measured, otherwise the measurement will be in error. If the compressions have been measured and adjusted from cards taken while the cylinders are cold, it is advisable to obtain another determination when the cylinders are hot, to see if there is any great variation under the two different conditions. In a new engine it is quite common for the compression in all cylinders to increase for a short time after the engine is put into service, as the piston rings and cylinder liners wear to a better fit, but this increase does not continue long. After an engine has worn-in, the most common compression adjustments required are for the purpose of increasing compression rather than decreasing it. This loss of compression pressure is due either to wear of parts or to leakage. These two causes will be considered separately and in detail, although in one case, that of leaky piston rings, the loss of compression is due to both causes combined.

The parts whose wear directly affects the compression are the crankpin and crosshead-pin bearings, and to a less extent the mainshaft bearings. The wear of these bearings is usually a gradual process and causes no sudden reduction in compression; individual bearings are adjusted from time to time, as required, and each time an adjustment is made it increases slightly the linear clearance between the top of the piston and the cylinder head. In the course of time this increase of clearance will decrease the compression enough to necessitate adjustment. It may sometimes happen that a bearing will run hot and cause the babbitt to run or

wipe enough to require rebabbitting one or both boxes, or the fitting of a spare box, in which case the compression may be changed enough to require readjustment.

The most frequent causes of loss of compression are leakage of air out of the cylinders, due to leaky exhaust valves, inlet valves, relief valves and air starting valves; leaky cylinder-head gaskets; and broken, stuck or worn piston rings. In the case of two-stroke-cycle engines of the valve-scavenging type, leaky scavenging valves may be added to this list. When the trouble is caused by leaky relief valves or leaky cylinder-head gaskets, no special investigation is required to locate the leaks, as they will make themselves known by the noise of the escaping air. A leaky air starting valve can be located by feeling the air pipe below the valve; if the valve leaks, the pipe will be hot. If the inlet valves draw the air in through individual pipes, a leaky valve will make its condition known by a loud whistling noise in the pipe attached to that particular valve, but where all the inlet valves take in air through a common pipe or manifold, the identification of the leaky one is not so easy. Leaky exhaust valves are revealed by a whistle in the exhaust line. In that form of construction characteristic of most large, crosshead-type engines, where the lower ends of the power cylinders are not inclosed within the housing, piston-ring leakage makes itself known immediately by the peculiar noises, varying in intensity from a sneeze to a loud explosion, made by the air and the products of combustion blowing past the piston rings and out of the open ends of the cylinders. In the case of trunk-piston engines, where the lower ends of the cylinders are inclosed within the housing, the noise can seldom be heard and the piston rings may leak for a long time without the knowledge of the engineer, unless indicator cards are taken or the rings examined, although leakage past the piston will always reveal itself by the smell of the crankcase when opened. If leakage past the piston rings is occurring, the normally bright wearing surface of each ring will be blackened at the points of leakage, and the blast effect of the gases will sometimes create a stratified appearance on the surface of the piston.

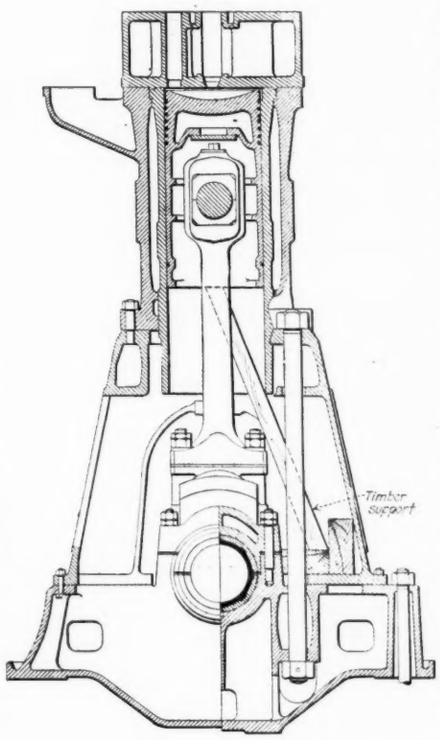


FIG. 2. SUPPORT FOR TRUNK PISTON

When low compression in one or more cylinders is shown by the indicator cards, circumstances will usually indicate the nature of the cause. If the engine has just been erected and there is no reason to suspect leakage, it is safe to assume that the linear clearance between pistons and cylinder heads has not been correctly adjusted; on the other hand, if the engine has been in service any length of time, the trouble will be found to be due to leakage at one or more of the points enumerated, unless the bearings have been adjusted frequently, in which case the decrease in compression will occur gradually. If leakage is causing the trouble, the point of leakage may be determined by a process of elimination. In most cases it will be found that the trouble is caused by leaky exhaust valves or piston rings. If any valve or cylinder-head gasket is found to be leaking, the procedure for correcting the trouble is obvious and need not be explained.

Leaks past the piston rings that are caused by wear of rings or liners may sometimes be stopped by peening the inside surfaces of the rings, to increase their tension. This peening should be done with a ball-peen hammer while the ring is held on a smooth metal surface, striking light blows with the hammer at a point directly above the point of contact of the ring and the plane surface, and rolling the ring until its entire inner surface has been peened. If the cylinder liners are worn oval, the only remedy is to rebore the liners or install new ones. The rules of the classification societies require that a number of spare piston rings be carried on all Diesel-motored ships, so that new rings are always available for replacing broken ones, and all well-equipped stationary plants carry an extra set. If low compression is due to excessive clearance between a piston and its cylinder head, this clearance must be decreased by lengthening the piston, piston rod, crosshead and connecting-rod assembly. As previously noted, the only practicable method for doing this is to add sheet-metal shims between the foot of the connecting rod and the top shell of the crankpin bearing. The engine builder usually furnishes a table showing the thickness of shims required for changing the compression any desired amount within the range of pressures that may be expected in practice. Having determined from the indicator card the amount it is desired to increase the compression and prepared shims of the necessary thickness, the crank to be worked on is placed near top center, and the weight of the connecting rod, crosshead, piston rod and piston supported by a bar placed through the guide and under the crosshead slipper, as in Fig. 1, or by some other suitable means. The crankpin nuts are then removed, the shaft jacked around until the top box is pulled away from the connecting rod, the lower box and crankpin bolts lowered away until the bolts are pulled out of the holes in the connecting rod, and the shims may then be slipped into place. This job may be greatly simplified if the shims are cut away on a radius, as shown in Fig. 3. If this is done, the crankpin nuts need not be entirely removed from their bolts and no support for the lower box need be rigged; the nuts are simply slacked off, the box pulled away from the rod enough to admit the shims and when the centering lug has been slipped through the center hole in the shims, the latter can be revolved into place.

If the engine is of the trunk-piston type, the piston can be supported as shown in Fig. 2. Two timbers, a trifle shorter than the distance between the piston and the blocking alongside the main bearings are inserted when the crank is on top dead center. Turning the flywheel will allow the weight of the piston and rod to rest on the timbers. After loosening the rod bolts, the wheel

can be turned until the crankpin bearing leaves the big end sufficient for the insertion of the shims.

Many operators are not familiar with the calculations necessary to determine the amount of shims required. These men must then use judgment in inserting additional shims. It is advisable, if the engineer does not have a well-defined idea of the amount needed, to

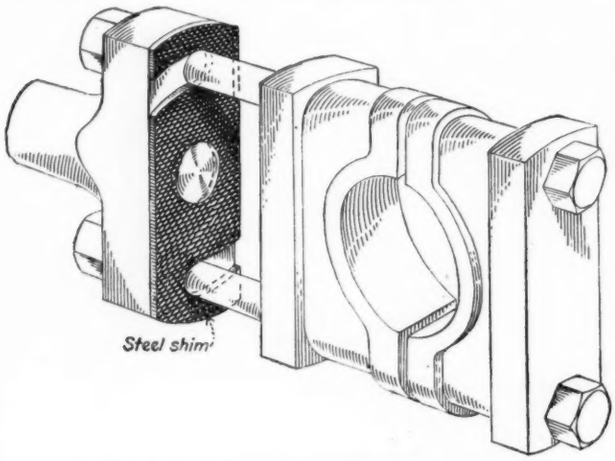


FIG. 3. ROD-END COMPRESSION SHIMS

insert a thin shim and by using the indicator to see if more are needed.

In some types of engine the piston head is made separate from the piston and is secured to it by means of a bolted joint, with a gasket to prevent water leakage out of the piston. When one of these heads is removed for any purpose, care must be exercised when replacing it to put in a gasket of the same thickness as the old one, since any change in this thickness will change the clearance and affect the compression.

A Self-Starting Synchronous Motor with a High Starting Torque

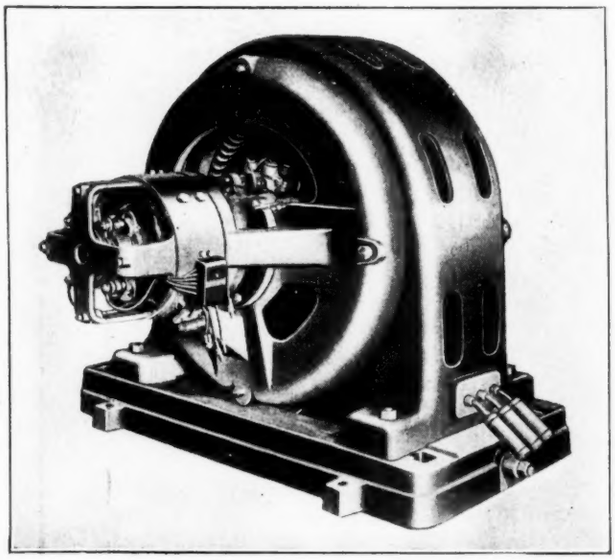
The need of a synchronous motor that will start and pull into step under heavy loads has prompted considerable research on the subject. The motor described in this article is one of the latest solutions to the problem.

Synchronous motors are made self-starting by the addition of a squirrel-cage winding in the pole shoes of the revolving field. When the armature is connected to the alternating-current supply with the field unexcited, the field structure acts like the rotor of an induction motor, the armature acting as the stator, and the synchronous motor starts up with the characteristics of an induction motor.

In order to obtain a good starting torque, it is therefore necessary to have a high resistance in the squirrel-cage winding at starting. On the other hand, it is also important that the squirrel-cage winding bring the machine as near as possible to synchronous speed even under full load, in order that little torque will be needed to pull the machine finally into step. This condition requires a low-resistance squirrel-cage winding. The combination of these two seemingly incompatible conditions has been effected by the Ideal Electric & Manufacturing Co., Mansfield, Ohio, in their new synchronous motors, by providing two parallel paths in the squirrel-cage winding, one high-resistance path of non-magnetic material, and one low-resistance path of magnetic material, such as cast iron or steel. The principle is based on the fact that the frequency of the alternating current induced in the secondary is equal to that of the line when the machine is about to start, whereas it becomes very low as the motor approaches synchronism, and is zero at exactly synchronous speed. On starting, therefore, the skin effect in the magnetic path of the secondary is so high that little current can flow through it. The effective resistance of the secondary is therefore only slightly less than that of the high-resistance path, and a high starting torque is obtained. When the motor approaches synchronism, however, the skin effect in the magnetic path disappears, and the latter carries most of the secondary current. The effective resistance of the secondary is therefore low, and the motor runs with a correspondingly small slip.

The foregoing principle is applied to the motor under consideration in a novel form. The two paths are combined in the shape of copper or brass tubing with a solid core of iron or steel bar. Due to the skin effect, the inner bars of magnetic material will carry little current at starting and the secondary resistance will be practically that of the copper tubing. This may be given any desired value by varying the thickness of the walls. When approaching synchronism, the iron core carries most of the secondary current, and the machine is brought so near to synchronous speed that the "snap" of the flux to the salient polepieces readily pulls the machine into step even against a full-load torque.

An interesting feature from the manufacturing viewpoint is the fact that only one diameter of tubing is used for all motor sizes, the secondary resistance being varied in the different types by changing the thickness of the tubing. All pole punchings are therefore made



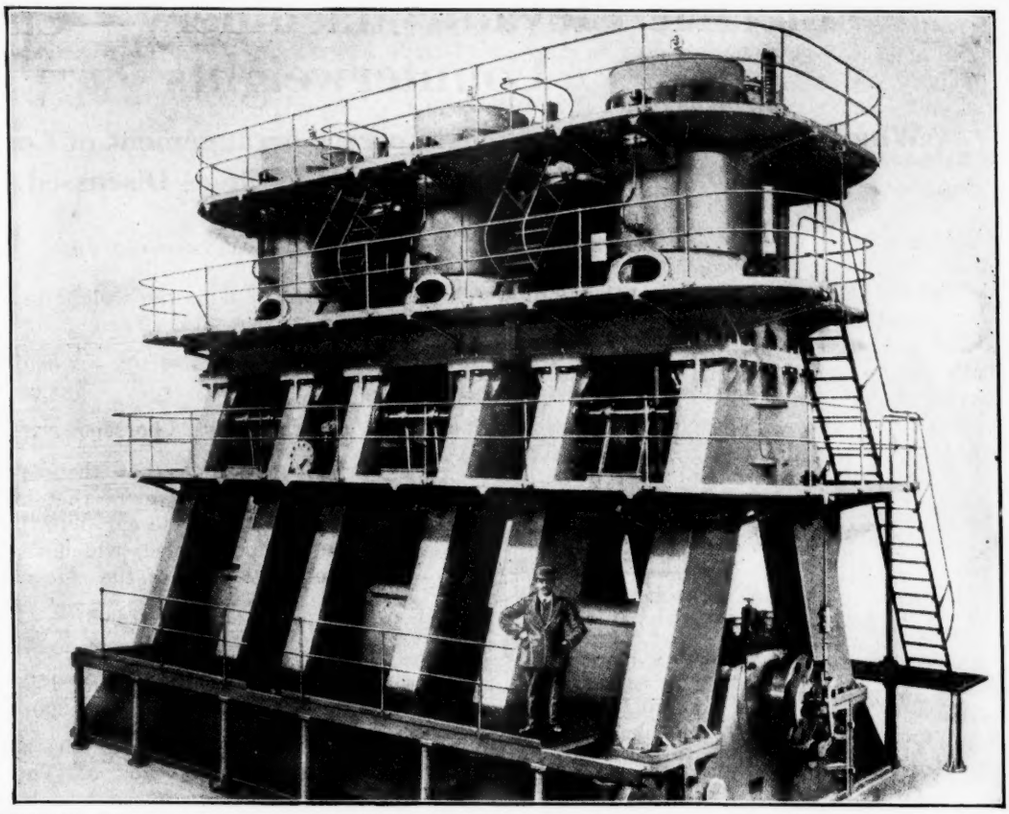
SELF-STARTING SYNCHRONOUS MOTOR

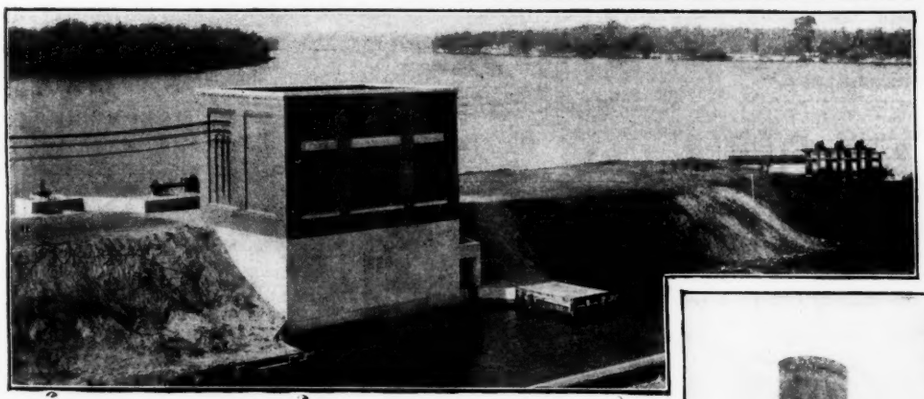
with a standard size of index dies. The bars are fastened to end-ring segments, which also serve as upper-coil supports for the field coils. The segments of the end rings are rigidly connected together by means of split-sleeves and taper pins.

Mechanically, the machines are sturdily built and planned for adequate ventilation. Another feature of interest is that the field leads are carried to the rings inside the collector-ring housing, and the brush holder is inclosed.

A big English rolling-mill engine, rated at a maximum capacity of 25,000 hp. at the full speed of 140 r.p.m. It is said to be the most powerful of its type ever built. Each of the three cylinders has a diameter of 45 in. and takes steam at 190 lb. per sq.in., superheated 100 deg. F. The stroke is 52 in., and it exhausts to a barometric condenser. The valve gear is of the Joy type and is designed to cut off steam up to 70 per cent of the stroke. The engine has recently been installed in the Middlesbrough steel works of the Cargo Fleet Iron Co., and is to be used to drive a train of 32-in. finishing rolls on joists up to 24 in. deep by 12 in. wide. The makers have guaranteed that when the engine is installed it will be capable of reversing four times in a minute.

—*Courtesy of the Engineer, London.*

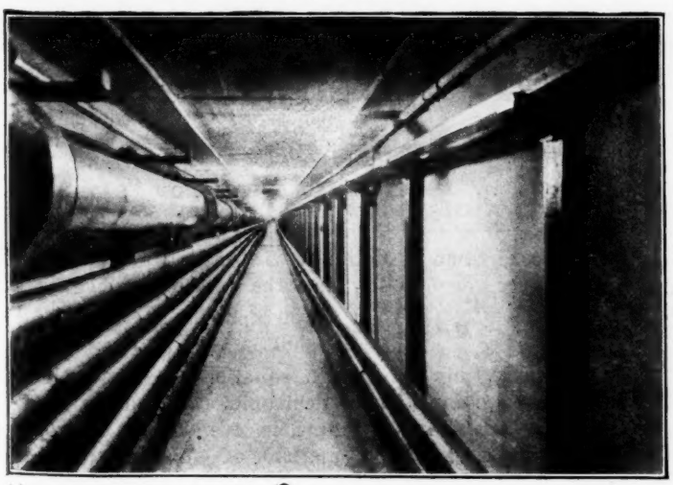




Left — This attractive little plant was recently completed for the Mays Landing (New Jersey) Water Power Co. Two 250-hp. water-turbines, working under a 12-ft. head, are used in conjunction with steam units to run the company's cotton mill.

Below—Stacks and breechings of the Philadelphia Electric Co.'s new Delaware Station, described in *Power* for May 24. By carrying the flues up over the roof, the height of the building was considerably reduced.

Below—A pipe alley that seems to stretch away for miles and miles. Actually, it is 1,000 ft. long. It carries an 8-in. high-pressure main and other pipes from the central power house to the new Parliament buildings in Winnipeg, Canada.

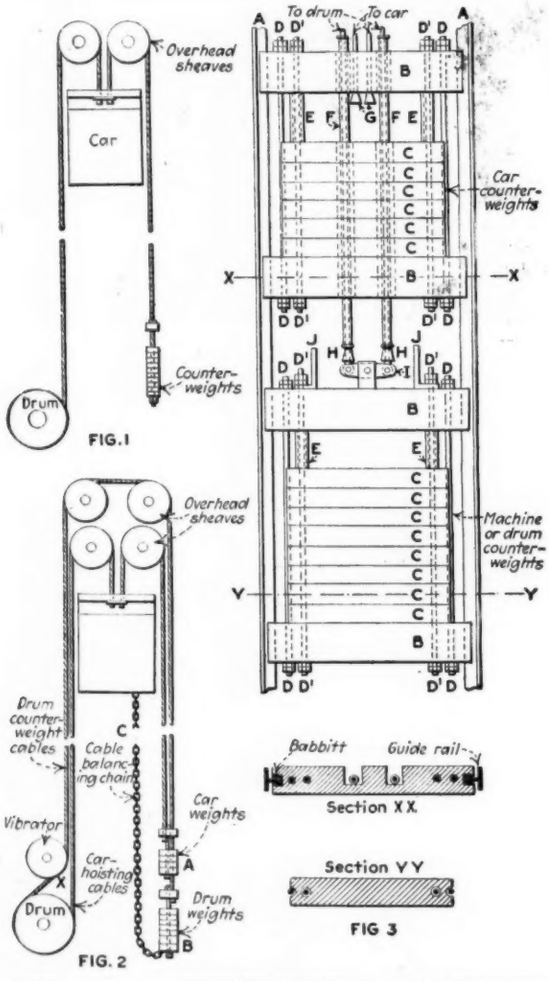


Electric Elevator Machinery—Car and Counterweights

Why Counterweights Are Used—Correct Arrangement of Counterweights—Types of Buffers and Guide Shoes Discussed

By M. A. MYERS
Electrical Engineer, The Maintenance Company, New York City

COUNTERWEIGHTS or balancing weights are used on elevator machines to equalize the load and stresses on the motor and machinery for both the up and down motions. Consider an elevator having no counterweights, then work will have to be done by the motor in lifting the empty car, and this will increase approximately in direct proportion as the



FIGS. 1 TO 3.. COUNTERWEIGHT ARRANGEMENTS ON ELEVATOR MACHINES

car is loaded. Gravity will lower the car, and to prevent overspeed on the down motion the motor will be converted into a generator to an extent governed by the load in the car.

Suppose it is desired to lift 1,500 lb. 150 ft. per min. and the car alone weighs 1,000 lb. The formula for motor horsepower is

$$HP. = \frac{W \times S \times 2}{33{,}000}$$

in which W is the weight to be lifted and S the speed in ft. per min. Then

$$HP. = \frac{(1{,}500 + 1{,}000) \times 150 \times 2}{33{,}000} = 22.7$$

or practically 23 horsepower.

Now assume that the elevator is counterweighted in the usual manner; that is, by an amount equal to the weight of the car plus the amount of the average load to be carried, which is generally assumed to be about one-third of the rate capacity. Then

$$HP. = \frac{(1{,}500 + 1{,}000) - (1{,}000 + 500) \times 150 \times 2}{33{,}000}$$

$$= \frac{1{,}000 \times 150 \times 2}{33{,}000} = 9.1$$

or less than 10 hp. as the maximum required of the motor on the up motion. The extreme power required from the motor on the down motion will be to lower the

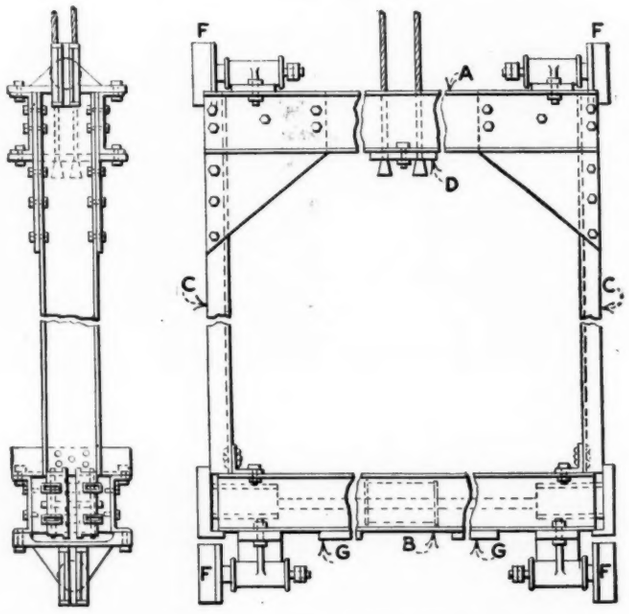


FIG. 4. ELEVATOR CAR SUSPENSION FRAME WITH GUIDE SHOES AND SAFETIES

empty car, when it will have to raise the amount of overbalance, or 500 lb., and the required power is

$$HP. = \frac{500 \times 150 \times 2}{33{,}000} = 4.5$$

Obviously, any scheme to equalize the motor loads in an average day's run is desirable, and to use a 10-hp. instead of a 23-hp. machine is even more desirable. Fig. 1 shows a simple method of applying counterweights to an elevator, but it is evident that the balance

weights cannot equal the weight of the car, for then it would be impossible to lower the latter. It is therefore customary to divide the weights into two groups, as in Fig. 2, in which *A* represents the car counterweights and *B* the machine, or drum counterweights. The car counterweights relieve the drum, bearings, lifting cables, etc., of the strain of that portion of the

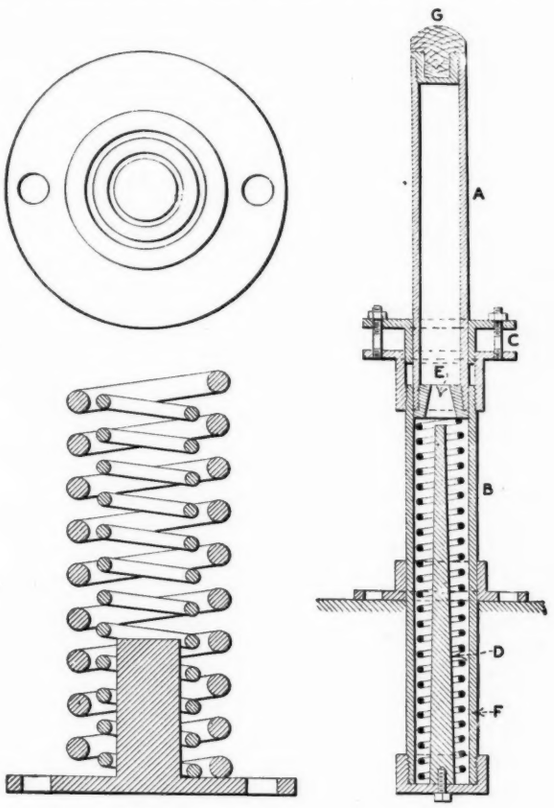


FIG. 5 FIG. 6

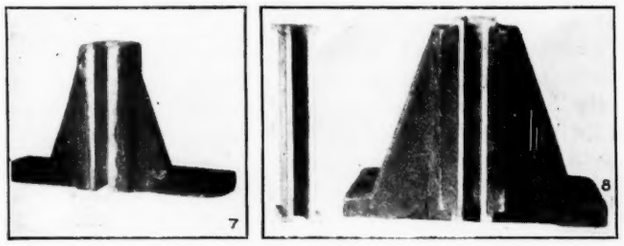
FIGS. 5 AND 6. TYPES OF CAR AND COUNTERWEIGHT BUFFERS

weight of the car that is balanced by them. They must be sufficiently lighter than the car so that there will be no disagreeable wavering of the empty car on the down motion should there be uneven guide-rail friction, and also so that there will be no unpleasant rebound on bringing the machine to a stop. Usual practice is to make the car counterweights 66 to 70 per cent of the weight of the car.

An ordinary arrangement of counterweights for drum-type machines is shown in Fig. 3, the upper group being the car weights and the lower the machine or drum weights. *A* and *A* are the "T" iron or steel guide rails; *B* the header or guide weights; *C* the sub-weights or filler weights; *D*, frame rods; *D'*, safety rods; *E*, spacers or separators (pipes); *F*, rope sleeves or protectors; *G*, plain sockets, baskets or rope-end thimbles; *H*, open-type sockets; *I*, strain equalizer; and *J*, bumpers.

Only the header weights are machined or babbitted to fit the guide rails. Sometimes the sub-weights may conform in length and appearance to the header weights, this being done to gain weight where space is limited, but it will usually be found that the sub-weights are a loose fit to the rails and do no guiding. The frame rods *D* make for ease of installation and adjustment of weights, the safety rods *D'* only being inserted and bolted fast after the proper number of weights is determined.

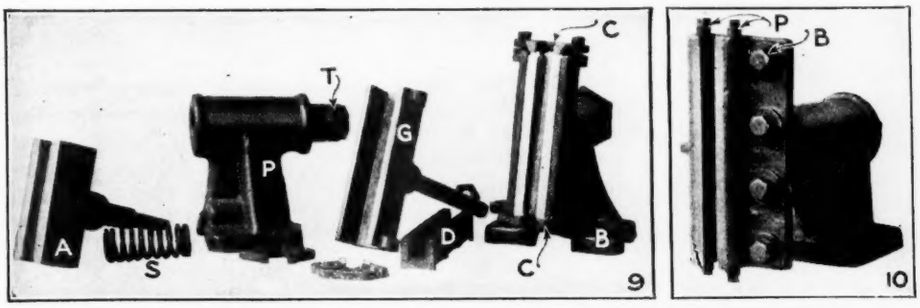
The car weights should always be above the machine weights. If this order be reversed and the machine



FIGS. 7 AND 8. SOLID TYPES OF GUIDE SHOES

weight cables should break or pull out of the sockets for any reason, they would land on the car weights and the car would be pulled in to the overhead work, with probable serious consequences. Nevertheless, elevators may be found now and then with the correct order of weights reversed.

For high lifts the weight of the several cables make an appreciable difference in the balancing of a car, for when the car is at the bottom of the hoistway, there must be included with its weight the weight of the cables between it and the overhead works. And when the car is at the top of the hoistway, practically the same cable weight must be added to that of the counterweight. It is desirable in such cases to compensate for this variation in balance by means of a chain or chains as shown at *C*, Fig. 2, where the chain is fastened to the car and counterweights. The chain should have equal weight foot for foot with the cable for which it compensates, and it is usually better to have two small chains than one heavy one, to minimize rattle and noise. Where quietness is particularly essential, the chains are incased in canvas or leather casing, or they may have sash cord sewn through the links.



FIGS. 9 AND 10. ADJUSTABLE TYPES OF GUIDE SHOES

The car proper is built on an iron or steel framework variously known as the safety girdle, suspension frame or car sling. A typical example is given in Fig. 4. *A* is called the crosshead or yoke, *B* the safety plank,

which embraces the car safety, to be described in detail in a later article; and *C* stiles, all these parts being built of channel iron or steel. *D* is the hitch plate or cable anchorage, *F* the guide shoes, and *G* the bumper plates, directly under which, on the bottom of the hoistway (the pit), are located buffer springs for ordinary speed, up to 250 ft. per min., or oil buffers for high-speed machines.

Buffer springs are made up of two, sometimes three, heavy spiral springs, right- and left-hand, one placed within the other as shown in Fig. 5. Oil buffers, Fig. 6, are made up of a piston *A* fitted to a cylinder *B* provided with a stuffing box *C*. The cylinder is filled with oil and has a tapered valve stem *D* which, by progressively closing the valve orifice *E* of the piston, gradually increases the resistance of the buffer to compression. The spiral spring *F* resets the buffer when the load is removed from it, and *G* is a rubber cap. Spring or oil buffers are installed under both the car and the counterweights and are intended to reduce the shock should the car or weights accidentally land, when the brake does not hold properly or from some other mishap.

Guide shoes of various types have been developed and are in use, some of which are shown in Figs. 7 to 10. Fig. 7 is an ordinary solid cast-iron shoe with a babbitt lining. This type of shoe has disadvantage in that it lacks resiliency, the means provided to take up the wear are not all that could be desired and it requires considerable time to reline the shoe on the job or it must be removed from the car and taken to a machine shop. The latter objection has been overcome by using a die-cast lining, as in Fig. 8. These linings can be readily installed by removing one guide shoe at a time, taking out the old lining, placing in the new and bolting the shoe back in place. This considerably reduces the time required to install new linings, compared with the time required for the solidly lined shoes.

To provide a guide shoe that would have resiliency and that may be easily adjusted, the type Fig. 9 was developed. It consists of a shoe *G* held in a pedestal *P* against a spring *S*. Correct tension on the spring is obtained by adjusting the threaded sleeve *T*. The shoe may have a solid lining as shown at *A* or a die-cast lining *D*. The die-cast linings can be readily installed by removing the top and bottom castings *C* and *C*, without disturbing the pedestal. With this type the spring can be adjusted so that the shoes are in contact with the guide rails at all times, consequently the car does not bang the shoe on the rails as with the solid type, and is claimed to result in a smoother running car. However, this latter feature is one that is open to discussion and the solid type of guide shoe has its advocates. The completely assembled guide shoe is shown at *B* in the figure. In some cases the lining consists of three brass gibs, one at the back and one on each of the two sides.

None of the type so far described provides any means of adjusting for side wear. In the type Fig. 10 arrangements have been made to accomplish this end. The shoe is of solid brass with one side made adjustable, by being made up separate from the rest of the shoe and provided with elongated bolt holes. This side is held in place by four bolts *B*, and the elongated holes allow a certain amount of side adjustment. Plugs *P* are provided as means of lubricating the shoe. This guide shoe is expensive to construct and since after the wear reaches a certain point they must be replaced, the renewals are expensive. As a result this type has never come into very general use. The type shown in Fig. 9 or similar types are being used to a greater extent than any other.

Midway Gas-Burning Steam-Power Plant

By L. J. Moore
Electrical Engineer, San Joaquin Light and Power Corporation

THERE are a number of distinctive features that will be of interest to steam-station engineers in the Midway steam plant of the San Joaquin Light and Power Corporation, now under construction at Button Willow, Cal. At this time one 12,500-kva. turbo-generator is being installed, but the building, cooling system, switchyard, etc., are being laid out in such a way that extensions to provide for three more units of the same capacity can be made. The building is of reinforced-concrete construction with steel-sash windows. The benchboard room will be lighted by a skylight, and no outside windows will be provided except between this room and the main generator room.

Steam for the turbine will be obtained by burning natural gas under 8 Stirling boilers, each having 8,000 sq. ft. of heating surface, set in four batteries of two each. The natural gas comes directly from the Elk Hills oil field at the edge of which the plant is located. An 8-in. gas main, 9 miles long, is being constructed from the compressor plant of the Midway Gas Co. to the plant. Four boilers are being equipped with Apex gas burners and four with the Duquesne burners. All boilers are also equipped with Hammel oil burners, and a 5,000-bbl. fuel-oil tank is being installed to provide for emergencies. The four stacks are 125 ft. high, 7 ft. 6 in. diameter, and constructed of sheet steel which varies in thickness from $\frac{3}{8}$ in. at the bottom to $\frac{3}{8}$ in. at the top.

The boilers operate at 250 lb. gage with 125 deg. superheat giving a total steam temperature of 531 deg. Makeup water is supplied from wells, six of which have been drilled to a depth varying from 350 ft. to 550 ft. Four wells have 12-in. steel casings and two have 16-in. casings. The water obtained has been carefully analyzed and found satisfactory for boiler use.

A 30,000 sq. ft. surface condenser is provided for the main turbine. Circulating water will be cooled in a spray pond 200 x 300 ft. in area, and about 5 ft. deep, provided with 360 spray nozzles. The main circulating pump for this unit is a 30-in. centrifugal, driven by a 150-hp. steam turbine through reduction gears. An auxiliary pump of similar capacity, but electrically driven is provided as a stand-by. Future units will probably have a steam pump for each, but the present electrically driven spare will do for the entire installation. Makeup water for the spray system will also come from the wells. Two pumping plants are to be installed. Each pumping plant will have a large deep-

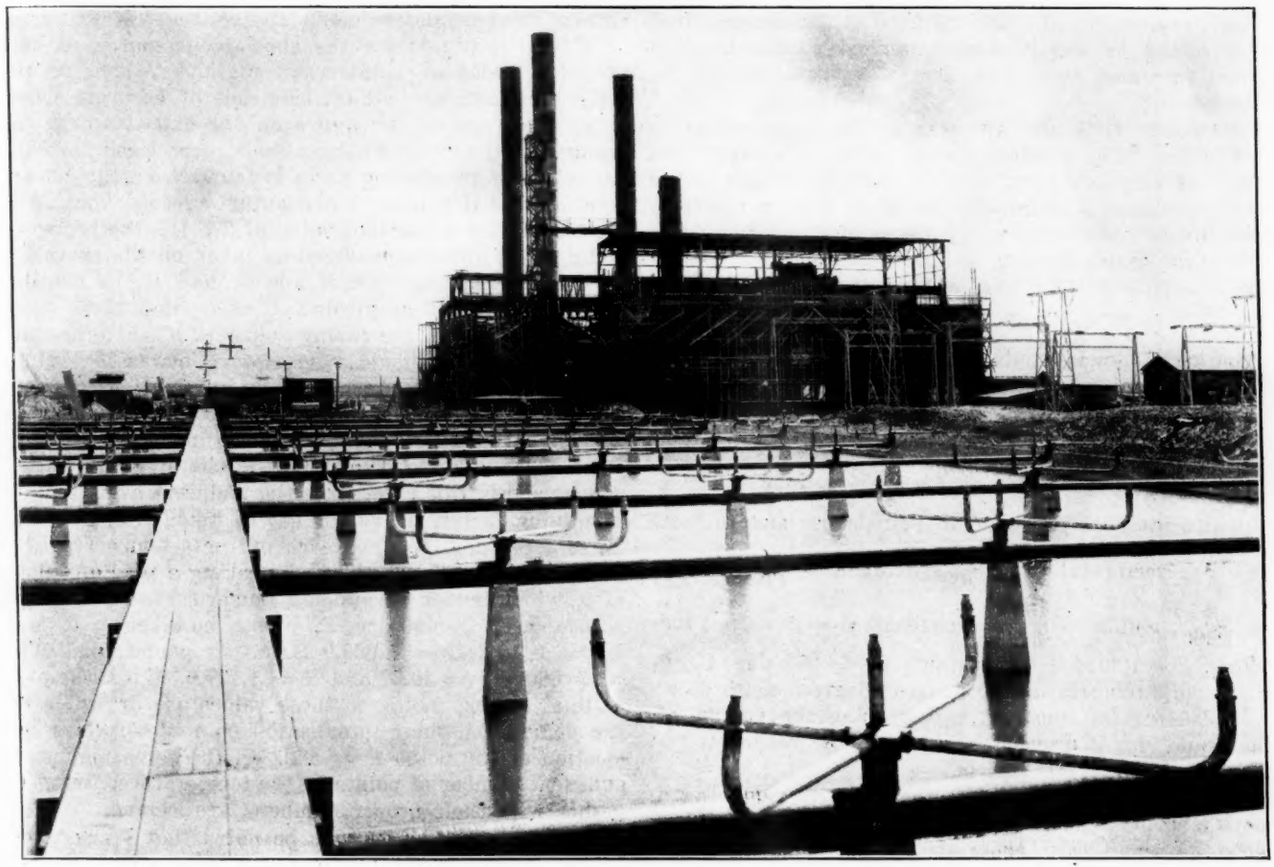
well pump which pumps three wells. Centrifugal pumps will take the water from the discharge of the deep-well pumps and will discharge it into a 20,000-gal. steel tank mounted at an elevation of 50 ft. From the tank the water will enter the main water system which will supply makeup for both the boilers and spray system as well as to the other minor uses about the plant.

It is expected to keep a careful check on the economy of the steam end of this plant, so a very complete set of measuring equipment is being installed. Bailey boiler meters are being placed on all boilers, a V-notch meter measures the boiler-feed water and a venturi meter is being installed in the condensate piping. A Cochrane water meter is being installed and so piped that it can be placed in either line and used to check the other meters. The gas will be measured by orifice meters. Calorimeter readings on the gas fuel and CO_2 measurements on the flue gas will be provided for and observations made twice daily.

The generator is a 60-cycle, 11,500-volt machine. The condenser is mounted on the ground floor of the building with the turbine and generator just above it on a level with the switch-gallery floor. The switch gallery is a two story structure on the opposite side of the turbine room from the boilers. Local service switches and transformers together with exciter and field panels are located on the ground floor of this part of the plant with the bench board, main generator switches, etc., on the second floor. As already noted this is on a level with the generator foundation.

Two exciters are provided at this time, a 150-kw. 250-volt turbine-driven unit and a 170-kw. 250-volt motor-driven unit. Each is capable of exciting two generators of the capacity of the first unit. A 15-kw., 250-volt motor-driven control generator has been provided but, a double-throw switch arrangement makes it possible to operate the electrically operated switches from either of the two exciter buses in emergency. Very complete relay protection for the generating unit and transformers is provided.

The step-up transformers are three single-phase 4,250-kva., 11,500-volt to 69,300/120,000 star-connected units with one spare. They are outdoor type as is all of the high-voltage equipment. Circulating water from the transformers will be supplied from the main water system and will be discharged into the spray pond. High-tension buses and disconnect switches are mounted on steel structures in the switch yard. Some of these structures are shown in the accompanying photograph, which was taken on April 6, 1921. Construction work is expected to be far enough along to permit operation by the latter part of June.



COOLING POND FOR MIDWAY POWER STATION; PLANT UNDER CONSTRUCTION IN BACKGROUND

The plant is not located near any city, so cottages for the operators were of necessity constructed by the company on its property. These are of attractive design and present the appearance of a small city in themselves. A small refrigerating plant has also been provided to provide for the needs of the operating force.

All design and construction work has been done by the operating department of the company under the supervision of E. A. Quinn, general superintendent.

Total Heat of Steam

By M. J. Eichhorn

The series of steam formulas developed by Professor Callendar are given by Smith and Warren in two articles in *Engineering*, London, Dec. 1 and 8, 1911. These formulas have been used in calculating two sets of steam tables, differing considerably in arrangement and range of pressures and giving results that are slightly different. I have taken these formulas and calculated the results that they give up to the pressure of about 1,500 lb. per square inch, tabulating the data in the form of nomograms and combining with the same the data on the temperature of saturated steam, given by Henning, Holborn and Baumann. While, of course, such results are only slightly supported by experimental evidence, they are probably the best we have at the present time, and owing to the "thermodynamical consistency" of these formulas, they have come into considerable use abroad.

Professor Callendar remarks in the introduction to his tables: "The absolute values are not known to this order of accuracy (0.01 deg. C.), but exactitude in the relative values is extremely useful in solving problems relating to the discharge of steam and in other cases where the result depends on small differences." Callendar's formula for the total heat of dry steam is

$$H_1 = 594.7 + 0.477\ T_1 - Yp$$

using the following notation:

H_1 = Total heat of steam above 0 deg. C. in kilogram-calories per kilogram;

T_1 = Temperature of steam in degrees centigrade;

$Yp = j\left[(n+1) \times C_o \left(\frac{\Theta_o}{\Theta}\right)^n - b\right] p$, in which p = absolute pressure of steam in pounds per square foot, $j = \frac{1}{A}$ = reciprocal of Joule's equivalent = $\frac{1}{(778 \times 1.8)} = \frac{1}{1{,}400}$, and $n = \frac{10}{3}$; consequently $n + 1 = \frac{13}{3}$; further, $C_o = 1.2014$ = a constant; $\Theta_o = 273$ deg. C.; Θ = absolute temperature of steam in degrees centigrade; $b = 0.016$ = a constant, representing the volume of the liquid, for a discussion of which the reader is referred to the original article.

In the formula given here, the quantity requiring a more laborious calculation is Yp, and in order to simplify the same, let p_1 equal absolute pressure of steam in pounds per square inch, and T_1 equal temperature of steam in degrees centigrade. Then $jp = p_1 \times 144 \times 1{,}400$; $\Theta = T_1 + 273$ = absolute temperature.

The substitution of the value of the constants gives

$$Yp = p_1 \times \left(\frac{144}{1{,}400}\right) \times \left[\frac{13}{3} \times 1.2014 \times \left(\frac{273}{T_1 + 273}\right)^{\frac{10}{3}} - 0.016\right].$$

Further observing that $\left(\frac{273}{T_1 + 273}\right)^{\frac{10}{3}} = \frac{1}{\left(\frac{T_1}{273} + 1\right)^{\frac{10}{3}}}$ and

substituting the English units, the formula becomes

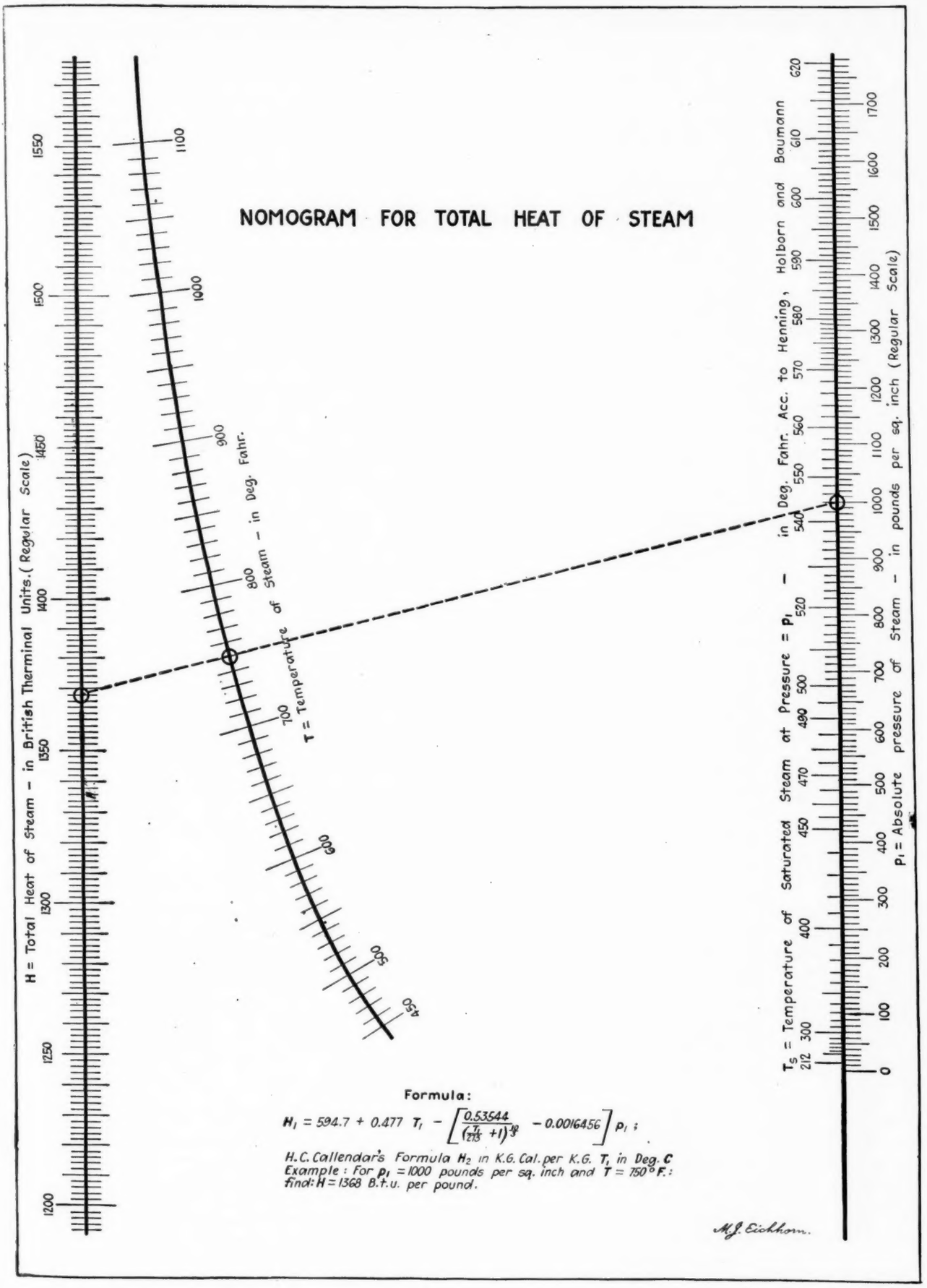
$$H_1 = 594.7 + 0.477\ T_1 - \left[\frac{0.53544}{\left(\frac{T_1}{273} + 1\right)^{\frac{10}{3}}} - 0.0016456\right] p_1$$

This equation is seen to be of the general form, $H = K + K_1 T + K_2 f(T) p$, in which H, T and p are the variables with suffixes removed and K_1, K_2 and K_3 are constants. This equation can be represented nomographically by two straight regular scales for H and p_1 and a curvilinear scale for T, because for any particular value of $T = K_4$ a constant, $H = K_5 + K_3 K_4$; and $K_5 = K_3 f(K_4)$. The resulting nomogram for total heat is shown on the opposite page. It is to be noted that this has been recalculated throughout for the customary English units, and that it is read by passing a straight line across the nomogram so as to connect two of the given values, and reading the third at the intersection point of the movable line and the proper scale, a transparent ruler being most suitable in determining the straight line.

The work involved in constructing a monogram of this kind is naturally quite considerable, but the process is very simple once the character of the supporting scales has been determined. In this case the scales for the total heat and for the absolute pressure are both regular scales of uniform graduations, which do not offer any difficulty other than that of accurate drawing. They are in the figure on the opposite page arranged as the top and bottom scale respectively, and the direction of numbering them is found from the consideration that if p_1 in the equation is increased, then H_1 is decreased, for a constant value of T_1. If, therefore, an arbitrary point is considered as taken on the curve for T between the lines for H and p_1, and if the movable line is considered as pivoted in this point, then, when one moves toward increasing values of p_1, the other end of the same line should move toward increasing values of H. This will be the case if the graduations on both the H and the p_1 scales are numbered with numbers increasing from left to right, as shown in the figure. The next question is to determine the useful range of the scales, and in this case, since the temperature is the determining factor, the range may be taken from 450 deg. F. to 1,100 deg. F. For each of these temperatures a pair of values are calculated, by taking a pair of values of p_1, which render the simplest numerical work. For instance, for $T = 450$ deg. F., p_1 may be taken $= 0$, thus $Yp = 0$, and $H = 1.269.9$ B.t.u. per pound; and with $p_1 = 600$, $Yp = 40.27$ and $H = 1{,}197.6$. When the pair of lines corresponding to these values are drawn in on the nomogram, their intersection point determines the location of the point $T = 450$. In the same manner a sufficient number of points on the temperature curve, together with their proper numbers, are located.

In this connection it may be noted that Marks' and Davis' steam tables give, for saturated steam at a temperature of 544.5 deg. F. and a pressure of 1,000 lb. per square inch absolute the value $H = 1{,}202$ B.t.u. per pound, while the Callendar formula gives $H = 1{,}228$ B.t.u. per pound. According to the former, H reaches a maximum value at 480 deg. F. and at a pressure of 565 lb. per square inch, apparently indicating that the total heat is decreasing beyond this point, while the temperature and pressure are both increasing. In this case, at least, it would seem that the Callendar formula is the more reliable.

The mean British thermal unit (B.t.u.) is defined as the $\frac{1}{180}$ part of the heat required to raise the temperature of 1 lb. of water from 32 deg. to 212 deg. F. This is substantially equal to the heat required to raise 1 lb. of water from 63 deg. to 64 deg. F. In countries that have adopted the metric system, engineers employ the kilogram calorie, which is equal to 3.968 B.t.u.


NOMOGRAM FOR TOTAL HEAT OF STEAM
H = Total Heat of Steam – in British Thermal Units. (Regular Scale)
T = Temperature of Steam – in Deg. Fahr.
T_S = Temperature of Saturated Steam at Pressure = p_1 – in Deg. Fahr. Acc. to Henning, Holborn and Baumann
p_1 = Absolute pressure of Steam – in pounds per sq. inch (Regular Scale)
Formula:
$H_1 = 594.7 + 0.477\ T_1 - \left[\frac{0.53544}{\left(\frac{T}{213}+1\right)^{3.8}} - 0.0016456\right] p_1$;
H.C. Callendar's Formula H_2 in K.G. Cal. per K.G. T_1 in Deg. C
Example: For p_1 = 1000 pounds per sq. inch and T = 750° F.:
find: H = 1368 B.t.u. per pound.
M.J. Eichhorn.

The Effect of Compression on Fuel Consumption

By L. H. Morrison

The fact that the Liberty motor, using gasoline and operating on the standard Otto cycle, is able to deliver a brake horsepower at the expense of but one-half pound of fuel, is in striking contrast to the usual efficiency of gasoline motors. Many engineers cannot understand the Liberty efficiency when it is compared with the fuel consumption of one pound per brake horse-

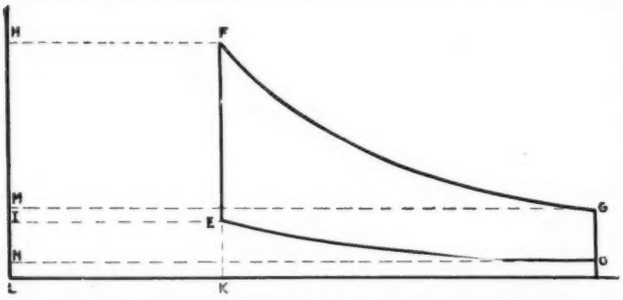


FIG. 1. OTTO CYCLE GAS-ENGINE DIAGRAM

power-hour which prevails with most gasoline engines. While there are several factors that tend to increase the efficiency of the former engine, the underlying cause is the increased compression pressure carried. The average gasoline engine operates with less than 70 pounds compression, while the Liberty has over 2½ times this compression.

In Fig. 1 is shown an indicator diagram from a gas engine operating on the Otto cycle; the distance from the base line represents the pressure in the cylinder at any set point in the piston stroke, while the distance from the vertical line *HL* represents the cylinder volume between the piston and cylinder head at this point in the stroke. If a charge of air and gas vapor is compressed in the cylinder, the pressure and volume changes follow the line *OE*, and the charge is exploded at the end of the piston stroke at *E*, where the pressure is 60 lb. per sq.in. and the line *EI* represents the clearance volume of the engine. The heat of explosion or combustion causes the pressure to rise to *F*, the volume remaining the same. The expansion of the mixture then moves the piston forward, the cylinder pressure and volume changes following the curve *FG* to *G*, where the gases are allowed to pass out the exhaust valve. For purposes of clearness the exhaust and suction strokes have been omitted since the two cancel each other.

Now, as already stated, a certain amount of gas mixed with air was drawn into the cylinder occupying a volume and at a pressure represented by the point *O*. At the end of compression the pressure and volume are represented by the point *E*. At the moment the gases explode, the pressure increases to *F*, the volume remaining constant, having a value equal to that at *E*. This increase in pressure came from the energy within the gas charge released by the explosion, and the energy is represented to some scale by the increase in pressure between *F* and *E*, times the volume at the end of the stroke, or the area *EFHI*. At the exhaust the energy represented by the area *GONM* is wasted through the exhaust pipe. The work done by the engine is proportional to the area of the diagram *OEFGO*. Since the work done is equal to the difference between the energy added and the energy wasted through the exhaust, the work is also proportional to the area *EFHI*, the energy added, minus the area *GONM*, the energy lost. It is evident that the only way possible to increase the efficiency of the engine is to provide some means whereby this difference of the two areas is made greater and this can be done only by making the area *GONM* smaller; that is, reducing the energy thrown away.

In Fig. 2 the indicator diagram is again shown. If the compression is increased by lengthening the piston stroke, the diagram will appear as *OABD*. The energy released by the explosion with high compression is represented by *ABSR*. Since the volume V_o at the beginning of compression is the same with both high and low compression, the charge of gas is likewise the same in both instances. The area *ABSR*, representing the energy of the gas mixture released by the explosion at *A* with high compression, is then the same as the area *EFHI* with the low compression; that is, the heat added is the same with both compressions. As the burnt gases expand, pushing the piston outward, the pressure and volume follow the curve *BD*. At the volume indicated by the vertical line through *F* the pressure of the high-compression engine is, as shown, lower than the pressure in the low-compression engine at the volume *F*. That this is true is proved by the fact that the energy released by combustion is the same in both engines and the gases have performed work on the piston from *B* to *F;* therefore, if the added energy is the same and some energy is turned into work, the energy remaining in the high-compression engine at the volume *F* must be less than the energy in the low-compression cylinder at the same volume. The pressure must then be less than P_f of the diagram *OEFG*. Turning to the exhaust, it is seen that the pressure at the point of exhaust *D* of the high-compression diagram is then lower than the exhaust pressure *G* with the low-pressure diagram. The energy lost by the former is represented by the area *ODVN*, while the latter is represented by the area *GONM*, which is larger than *ODVN*. It follows that

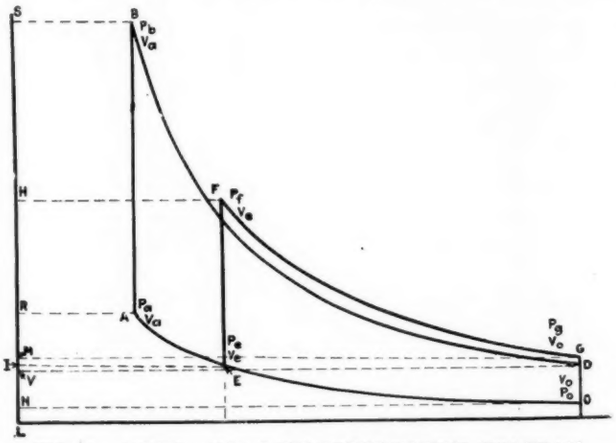


FIG. 2. HIGH- AND LOW-COMPRESSION DIAGRAM

with the high compression the heat lost to the exhaust is less than with low compression. The heat added in both cases is the same, consequently the energy converted into work in the high-compression diagram is greater than with the low compression, and the diagram *OABD* is larger than the diagram *OEFG*. It is for this reason that the tendency in explosion or Otto cycle engines is toward the use of higher compressions, 180 lb. being the maximum with gasoline.

EDITORIALS

The Price of Coal

LET all coal users congratulate themselves that the demand and purchase of bituminous coal has again improved sufficiently to justify the increases in production which the last three or four weekly reports of the Geological Survey have shown. The upward trend in coal production is, of course, a barometer of demand, and the demand is an indication that business is again taking heart and buying fuel in somewhat larger proportions.

But the increase of production means somewhat more than this. It means that users are beginning to purchase and presumably to some extent to stock fuel against the necessities of another winter. It will probably be some weeks yet before the demand and, therefore, the production reach what may be termed normal. Yet the tendency toward normal is encouraging. Stock reports of the Geological Survey showing supplies on hand in the bins of consumers and elsewhere give a picture for April first which is more encouraging than many have dared hope. It had been freely prophesied that when the stocks were inventoried there would be revealed sadly depleted reserves and distressing shortage. The commercial stocks found are not large, amounting to only about thirty-seven million tons, but they are not low enough to cause serious alarm nor any stampede toward purchase. On the other hand, they are not large enough to justify the coal purchasers collectively to sit back and decline longer to buy for storage, especially in those parts of the country where stocks of coal are vital to safe operation during winter periods. A sane but definite tendency toward a larger purchasing is bound to come. Frenzied buying or any panicky tendency even in any isolated locality has no excuse for existence.

The fuel purchaser very properly considers whether the present price for bituminous coal, either spot delivery or contract supply, is as low as he may reasonably expect. To gain a partial answer one need only compare the curves of production and of price for the past months. There is a surprising similarity in their shapes. As the demand diminished below normal, competition among sellers was increasingly keen; and while the low production of February and March prevailed, there was a condition of greatest stringency among the producers, who were compelled to dispose of much fuel known as "distress coal."

The price of coal has already begun to increase slightly, taking the country over. That it should do this is not surprising, for with even ten or twenty per cent increase in demand much, if not all, of the coal sold under extreme distress conditions disappears from the market. It is probable that as demand and production approach normal, there will be still further increases in the average realization on both spot and contract bituminous.

Just what is normal price is, of course, a question that no one can answer. The normal or proper price depends upon too many factors, labor, railroad rates and others. One can only guess at the influence of most of these, but the question of labor as an item in cost and railroad rates as an item in delivered price both have a few rather definite and more or less determinable influences.

It is estimated that in 1913 the total labor cost per ton of coal was between eighty-four and ninety-four cents. This figure is obtained by dividing total payrolls by total tonnage handled. On the average, therefore, one may take ninety cents as perhaps a typical pre-war labor cost. After numerous wage increases, the realization by labor during 1920 still varied with different fields. The labor leaders estimate that the average wage was $2.09; the National Coal Association upon the same wage estimated $2.19; on the average perhaps $2.15 is a fair figure to accept, or one hundred and forty per cent above pre-war. Naturally, the coal user paid this bill and perhaps some more to cover corresponding increases in expense for materials, management and overhead items.

For delivery of coal to market, estimates have been prepared by the wholesale coal association representatives which give an idea of the order of magnitude of the transportation charge which enters into the delivered cost of fuel. Taking several classes of fuel users separately and including the charges which railroads make to themselves for moving their own fuel, these estimates show that in 1920 about $2.50 per ton was required on the average to move the fuel from mine to user. This, according to the estimates of the wholesalers, is about a seventy-seven per cent increase above pre-war conditions, or in other words, the delivered price is now roughly one dollar higher than formerly because of railroad rate increases alone. If one considers only industrial fuel, the increases would probably be greater than this on the average for almost all parts of the country.

Taking all these points into consideration and remembering that prices for a fuel sold competitively always are likely to increase somewhat with increasing production and demand up to normal rates of production at least, it is clear that favorable contracts can probably be made today in almost any part of the country. In such contracts, however, should be ample provision which will guarantee prompt delivery of the right quality of fuel. And of course no one should make a contract based on delivered price that does not take account of possible savings due to lower railroad rates such as are freely being proposed today, as well as of lower wage agreements which may conceivably be entered into during the life of such contracts.

An unmistakable tendency to steady and persistent improvement in business is seen everywhere. It may yet require several months before the full benefit of this can be realized, but with the improvement of business will come increased need of fuel and an increased certainty that the fuel stockpile must be adequately filled before the winter season comes.

Reliability and Safety in Power-Station Operation

RELIABILITY, safety and safeguards against fires are so closely interrelated in the installation and operation of electrical equipment as to make it almost impossible to affect one without influencing the others. Reliability of service is of such importance that within economic limits everything should be done in design, installation and operation to attain it. Fortunately, those features that make for reliability in general also render the equipment safe to work around and reduce the fire hazard. Where high-voltage busbars are installed in fireproof compartments and securely mounted, not only is the reliability of operation improved, but the danger to life and property is reduced. Remotely controlled oil switches and their disconnects are generally placed in fireproof compartments, and when thus installed, have been considered reasonably reliable and safe. However, accidents have occurred by opening the disconnect switches before the oil switch was opened. Such happenings jeopardize not only the operation of the plant, but also life and property. By providing at the switch means to ascertain the position of the oil switch and also to open the control circuit before opening the disconnects, not only will the safety of the plant attendants be enhanced, but also the reliability of plant operation will be increased. This is practically true of every feature of the power plant—make it more reliable and the hazard to the attendants and property is reduced; or, vice versa, reduce the fire and operating hazards and the reliability of operation is improved.

In the promulgation of the National Electrical Code the prime purpose is the prevention of fires of electrical origin. The result of years of effort and experience, the Code is an index of the best American practice in electrical-equipment construction and installation, and its specifications represent a certain minimum standard of protection to be attained in all cases. In an article in this issue, "Protection of Power-Station Equipment," by Edgar P. Slack, the principal rules are discussed to bring out their direct bearing on safe electrical installations and operation in power stations. In studying these rules, it is clearly evident that if their original purpose, fire prevention, were eliminated, they would still be of great importance as a guide to reliable and safe electrical installations.

The reliability of the plant and equipment depend not only on quality of installation procedure, but also on the kind of housekeeping that is followed in plant operation. In this respect the Code specifications attempt to lay down rules to make the operation of the station safe. In the switchboard is centered the control of the plant; any serious failure here jeopardizes the operation of the whole plant. Therefore the Code specifies that there must be a free space of at least eighteen inches between the wall and apparatus on the board and that this space must be kept clear of rubbish and not used for storage. In general, if an electrical fire does start in a well-designed and maintained installation, the damage will be confined to the immediate vicinity of the failure. On the other hand, if dirt and rubbish are allowed to collect, as back of a switchboard, the fire is liable to spread over the entire board and endanger the operation of the whole plant. Thus reliability of operation, safety to attendants and prevention of fires in power stations are interwoven.

Prime Movers in Refrigerating Plants

IN THE early days of refrigeration the steam engine was used as the prime mover to the practical exclusion of all other powers. As with all infant industries the steam engines generally chosen were not by any means super-efficient, although they probably were the best procurable at the time. Even with the exhaust-steam demand of a distilled-water ice plant the cost of operation was much higher than at the present time.

As new forms of power came into use, such as electric motors, gas producers and oil engines, the steam engine as a refrigeration prime mover suffered a loss in popularity. Hundreds of these steam plants have been superseded by other powers, especially by electric motors. The cost of operation, which had been unduly high, was considerably reduced by the change. Nevertheless, the steam engine is still the most popular machine and is found in the majority of plants. Of late there has been a revival of interest in the steam unit. This is plainly a result of the advent of more efficient forms of the steam engine such as the poppet four-valve and unaflow engine.

In this issue appears an article dealing with the steam engine in refrigerating plants. The author of the discussion brings out the comparative merits of the several steam-engine designs and the method of selection that should be followed. The steam economy of the unaflow engine over a wide load range is such that at present many plants are being equipped with them. Having a steam consumption of twelve to fifteen pounds per horsepower, it would seem that the poppet-valve and unaflow engines would deliver power considerably below the cost with even the synchronous motor with its low electrical rate.

The author of the article referred to has plotted a chart for the several engine types, showing the tons of refrigeration per ton of coal against the suction pressure carried. On the basis of these curves electrical energy or other forms of power must be procured at very low rates to equal highly developed steam engines.

The steam engine has certain features of control that tend to make it most adaptable for refrigerating-plant work. The speed control of either synchronous motors or internal-combustion engines is not comparable with that of the steam engine. The wide speed range of the latter allows the compressor to be operated at the best speed for the prevailing load conditions.

Of late years engineers as a class have come to feel that the reciprocating steam engine has suffered a decline in popularity. While this is true in some industries, such as central stations, in the refrigeration field there is every reason to expect a continued use of the more improved types of reciprocating engines.

It is poor economy to shave costs in an industrial power plant and then waste the power through inefficient apparatus and operation in the factory. Here is a real opportunity for co-operation between the power plant and the production department in the way of cutting down expenses. Those whose work is to produce power should best understand its value and should be the more readily able to detect waste in its application.

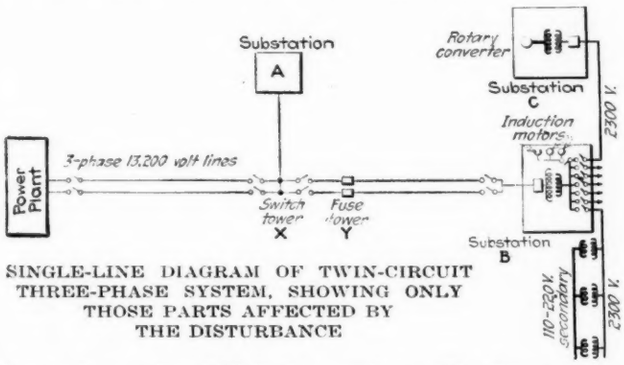
How is the heating system in your plant—does it need overhauling? If so, are you going to wait until the first cold snap comes and then rush madly about trying to patch it up?

CORRESPONDENCE

Operation of Three-Phase Motors on Single Phase

In the Feb. 22, 1921, issue of *Power*, Mr. Baxter mentioned a case of three-phase motors operating on single phase. Sometimes these cases are rather baffling and difficult to locate quickly. A case that occurred to the writer left a feeling of "nobody home" when it was finally cleared up.

The circuits were as shown in the diagram. Power was fed from the power plant over a two-circuit 13,200-volt three-phase line to the switching tower *X*, where various combinations could be made to maintain service and any line killed for repairs. The line to substation *B* was protected at fuse tower *Y* with expulsion-type fuses. The current was stepped down at substation *B* to 2,300 volts for transmission to substation *C*, where a rotary converter was operated continuously during the trouble.



SINGLE-LINE DIAGRAM OF TWIN-CIRCUIT THREE-PHASE SYSTEM, SHOWING ONLY THOSE PARTS AFFECTED BY THE DISTURBANCE

During a storm, trouble was reported on the secondary lighting from substation *B*, some of the lights apparently getting only part voltage. The trouble man reported that he had cleared the trouble. It was later discovered that he had switched the lamps all on the same phase, but as the load was small the unbalance was not noticed. No trouble was noticed at substation *A* and the three-phase motors at *B* operated satisfactorily. Excessive alternating current was noted on the rotary converter at *C*, however. The transmission lines were inspected, the patrolman being cautioned to pay particular attention to the switches at *X* and the fuses at *Y*; everything was reported O.K. A careful inspection of all equipment at *B* was made, and the only evidence of trouble was low voltage at the 2,300-volt transformer terminals.

As one line from *X* to *B* was out for repairs, it was necessary to kill the other line and inspect the fuses. They were removed and tested, disclosing that one was blown, but without leaving any indication visible from the outside. In most cases the end of the fuse wire was blown out and the protruding end served as a good indication, but this did not occur in this case. The three-phase motor at *B* and the rotary converter at *C* had therefore been running on single-phase, while supplying each other with three-phase power. If the power had happened to fail, however, the motors would have refused to start again. The net result was two days of trouble, considerable climbing over mountain lines and a general feeling of cheapness when the real trouble was found.

T. H. ARNOLD.

El Paso, Tex.

Relieving Thrust in Centrifugal Pump

We operate a motor-driven centrifugal boiler-feed pump at 300-lb. pressure. It is of the four-stage type with the water passages so arranged as to be hydraulically balanced, thus avoiding end thrust, and it is provided with a multiple-collar thrust bearing, which normally has to withstand very little thrust. Recently, however, this bearing burned out and was rebabbitted with the best metal obtainable, but when reinstalled, it was only with the most careful nursing that the temperature could be kept down to 180 deg. F. The trouble, obviously, was due to an excessive end thrust, but the cause for this was difficult to find. The rotor was in good condition. None of the water passages in the casing was stopped up. Apparently, the hydraulic balance was not disturbed. Yet there was no other cause for end thrust.

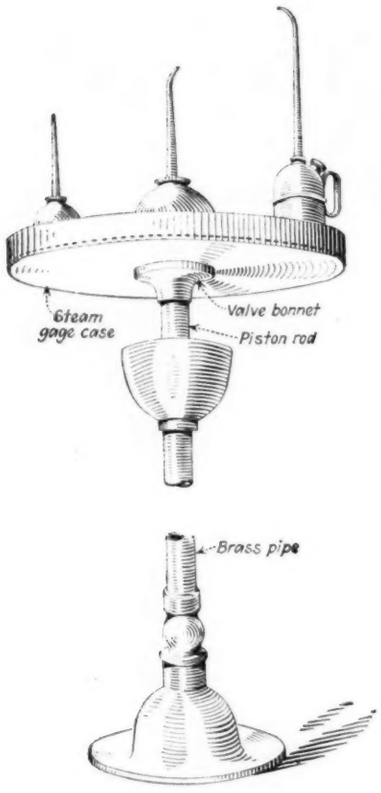
A rather intricate gasket made of drawing paper was used between the two halves of the casing. It was observed that this was blown out near the shaft, along the division wall between two of the stages. This, of course, unbalanced the pressure on one of the impellers, producing the thrust. However, it was found that a gasket could not be made to hold at that point, owing, as we thought at first, to the casing being somewhat warped. Finally, it was found that the stationary distance pieces around the shaft were a little too large and held the middle of the casing apart. The outside edge of the casing was sprung down by the bolts, but the middle was held up and did not grip the gasket firmly, which allowed it to blow out easily, with all the resulting troubles. We dressed down these distance pieces a little and put in a very thin cloth-rubber gasket, and the pump has been running satisfactorily ever since.

Wichita Falls, Tex. LESLIE R. GRAY.

Home-Made Oil-Can Stand

An oil-can stand was recently seen in a large power plant, which, although home-made and constructed from material found about the plant, was neat and attractive in appearance.

The base was made from the top of the diaphragm chamber of an old damper regulator, to which was screwed a ¾-in. brass pipe with a few ornamental pieces



HOME-MADE OIL-CAN STAND

at the bottom. On this pipe a brass receptacle for waste was secured about two-thirds up the pipe. The oil-can tray was the brass casing of a large steam gage, in which was a perforated disc on which the oil cans rested and which provided for any leakage to drop into the bottom of the tray. The oil-can tray was supported by a piece of piston rod on which a valve bonnet was securely placed to support the tray. The stand is nicely polished and, besides being useful, is ornamental as well.

W. R. SPECHT.

Baltimore, Md.

Freak Boiler-Setting Idea

A short time ago the fact that a bag had developed in the front sheet of a return-tubular boiler was called to my attention. Not long after this had been repaired, a similar bag developed in another boiler.

After some inspection it was found that both these boilers were more than an inch lower at the front than at the back ends, which condition, no doubt, was causing the accumulation of sediment, resulting in overheating of the plates.

While preparations were under way to remedy the trouble by leveling up the boiler and giving it a pitch toward the blowoff, it was mentioned by one of the employees that these boilers were ordered installed in the manner as stated so that the accumulation of sediment in the front end could easily be raked out through the handhole.

A. H. DAKIN.

Elmira, N. Y.

Aligning Engine Shafts

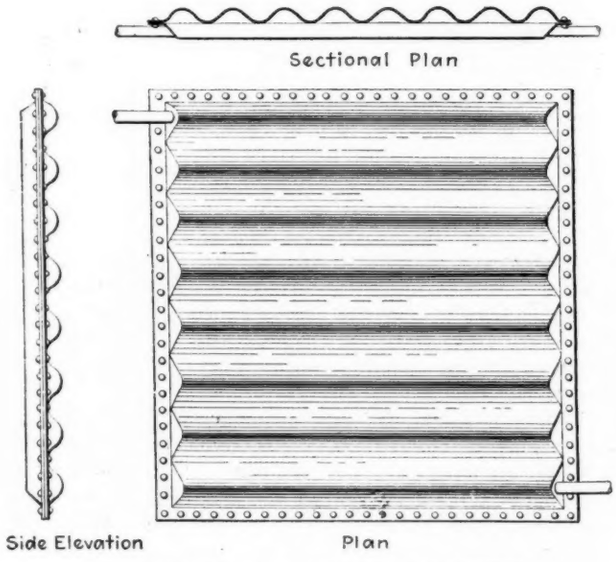
Referring to Mr. Harvey's letter in the May 3 issue of *Power*, page 714, I would advise using a flexible coupling in place of the plain plate coupling; the market affords several excellent designs of flexible couplings.

It is, of course, not a difficult matter to line up shafts in the beginning, but to expect them to stay so is quite another matter. If a disalignment of the shaft exists, it is only a question of time when it will fail.

New York City. L. COPLESTON.

Air-Cooled Condenser

A new condenser has been developed for use in localities where the cooling-water supply is small. This condenser is similar to the design shown in the illustration. A large amount of cooling surface is obtained at slight expense by the use of a light corrugated metal, a complete condenser unit being formed by placing two of the sheets together so that the corrugations cross, and sealing the four edges, inlet and outlet connections being made at diagonally opposite corners. A number of these units are then connected by suitable headers and placed in a tower something on the order of other well-known cooling towers, where the air rising either



CORRUGATED AIR-COOLED CONDENSER

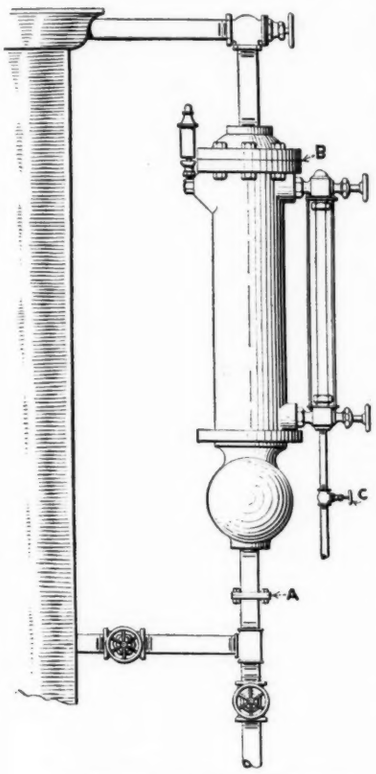
by natural or forced draft, will carry away the heat, condensing the steam inside the units. A small pump is provided to spray or sprinkle just enough water over these units to keep the surfaces moist, the evaporation of which will carry away more heat than the dry air alone, besides maintaining a lower temperature. The absolute limit of this condenser is the same as that of the cooling tower; that is, the "wet-bulb temperature" of the air.

R. E. THOMPSON.

Deming, N. M.

Valves and Unions for Water Columns

Although there may be good reasons for a difference in opinion concerning the kind of valves that are appropriate for water columns, it appears that there can be no doubt as to their necessity when all points in this connection are considered. Writers who claim that they are not necessary always refer to columns that are not fitted with high- and low-water alarms. Advocates of the plain water column favor a condition that is more dangerous than the presence of valves in the pipe connections.



FLANGE CONNECTIONS FOR WATER COLUMN

The illustration shows the plan adopted for water columns on six boilers in my plant. Originally, the bottom connection entered the side of the water column with a drip at the bottom. This is a good design where water that contains earthy matter in suspension must be used, but for my conditions, with comparatively pure water, it was not necessary, and as the columns could be placed nearer the boiler without this awkward design, it was discarded and bottom connection made as shown.

This connection was fitted with an all-brass union at the point *A*, but after the column had been taken down for repairs a few times the union leaked, and as it could not be packed, it was removed and an all-iron screwed union substituted. This eliminated the leakage, but the nut soon corroded fast in place and became a nuisance. It was taken out and a flanged union with four bolts substituted. When this union is packed, the gasket is heavily coated with graphite and oil on one side only. The joint can be broken several times without destroying the packing, and then it can be renewed.

For the top connection a flange joint at *B* is made a part of the column, and the gasket for this is treated with graphite and oil. The top of this was convex, hence it was difficult to remove and replace the nuts. To overcome this objection, pieces of ½-in. pipe were cut off in a lathe and used as washers on the bolts. Of course it was necessary to secure longer bolts for this purpose, but the nuts are now accessible and can be removed and are easily replaced.

One objection to the high- and low-water alarms is that they must be kept in repair. Their utility far exceeds this objection. Occasionally, a float becomes water-logged or some of the small parts fail, but by keeping a few of these parts on hand it is a short job to replace them.

Some of these connections are quite rigid, hence the upper connection cannot generally be lifted, but with flange unions the column can be easily moved horizontally into position.

When installing a new water gage, the first thing I do is to remove the pet-cock found in the lower connection and substitute two brass pipes and a globe valve, as at *C*. This does not leak readily, and when worn, a new disk can be put in. W. WAKEMAN.

New Haven, Conn.

Discharge-Pipe Connections to Centrifugal Pumps

A motor-driven centrifugal pump, for delivering water to the house tanks on the roof, had been installed in a ten-story building. The pump was designed for a horizontal discharge; that is, the flow through the discharge orifice was parallel to the base of the pump. Therefore when the pump was erected a short-radius elbow was bolted to the outlet, as shown by the heavy lines, to give the pump a vertical discharge.

When the pump was first put in service it was clearly evident that the motor that drove it was too small for the work. This was manifested by overheating of the armature and field coils and a continual sparking of the brushes. On account of these symptoms it was often necessary to cut out the centrifugal pump—as when an excessive demand for water would require a constant delivery to the house tanks—and put the direct-acting steam pump that had been installed as a stand-by to work in its place.

One day an engineer who had had much experience with hydraulic machinery dropped in on a casual visit.

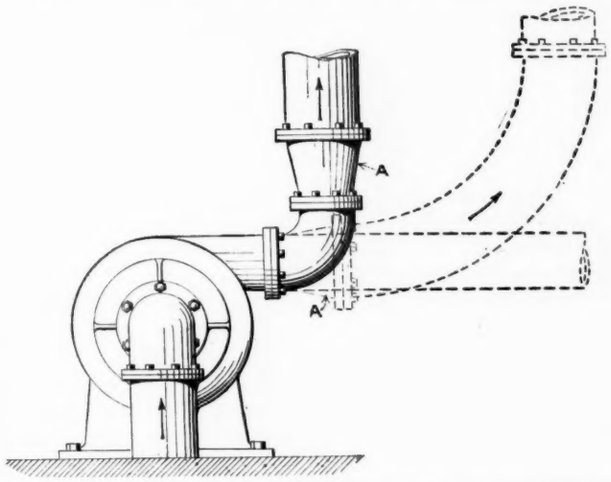


FIG. 1. SHORT-TURN ELBOW, LONG-RADIUS BEND AND DELIVERY PIPE OF SAME SIZE AS PUMP OUTLET

When the engineer in charge mentioned his pumping difficulty the visitor told him that if he would set the pump so as to give the discharge current a long upward sweep from the outlet, as indicated by the dotted lines, and thus reduce the delivery head about twenty feet, his trouble would probably disappear.

It is generally assumed that when a short right-angle turn is put in the discharge pipe from a centrifugal pump at some distance from the outlet orifice of the pump, say twenty feet or more, the friction-head against which the pump has to work probably is increased from three to six feet. But when the short right-angle

turn is bolted to the outlet the friction head may be increased anywhere from ten to twenty-five feet.

The reason for this is apparent when it is considered that the velocity of the water in the discharge pipe is much less than the velocity of the water as it is thrown from the periphery of the impeller in the pump casing. Assuming that the pump impels the water at a speed of, say, 30 ft. per sec., this initial velocity will be reduced to a certain minimum velocity by the time the water has reached the larger pipe. In a properly designed delivery pipe this minimum velocity will be about 10 ft. per sec. But as the water issues from the outlet it still retains the initial velocity of 30 ft. per sec. If the pipe is of the same diameter as the outlet, as indicated by the horizontal dotted lines, the minimum velocity will be attained when the water has traveled a distance equal to about thirty times the diameter of the outlet. But if the connection between the delivery pipe and the pump flares out, as indicated at *A*, the velocity will be slowed down to the minimum within a distance equal to perhaps not more than five times the diameter of the pump orifice.

Inserting a short-radius elbow anywhere in the delivery pipe will bend the column of water abruptly. Hence it will add materially to the frictional resistance. But it is obvious that the retarding effect will be much greater if the elbow is bolted directly to the outlet, where it must intercept the current flowing with the high initial velocity, than if it is placed farther along where the flow is slower. The increase of resistance will be in about the ratio of the higher velocity to the lower.

St. Louis, Mo. A. J. DIXON.

Redesigned Boiler Furnace Reduced Coal Consumption

In the April 5 issue of *Power*, page 556, is an article describing the effect of raising a horizontal return-tubular boiler so that the distance from the grate to the under side of the boiler is 27 in. instead of 16 in., as it had been for some years. The distance from the top of the bridge wall to the shell was at the same time increased from 9 in. to 14 in. To these increases in height a reduction in coal consumption of 1 to 1½ tons of coal per day was ascribed.

Although the boiler as originally set is unusually low, it should not be overlooked that the restricted area between the top of the bridge wall and the under side of the boiler was only at the center of the boiler. When changes such as this are made, other changes of a desirable nature are usually made at the same time. In addition the men always take more pains to fire properly in such cases, especially if there is any reason for feeling interested in the new arrangement.

While the change that was made was desirable, I have no doubt that the same evaporation could have been obtained with the original height of boiler, provided other things were the same and the firing was done with the skill that the situation needed. It should be remembered that the object to be attained is to burn the carbon to CO_2, and if this is done and everything is tight, the evaporation will take care of itself. There was plenty of height originally over the grate and bridge wall except at the center and plenty of room for perfecting the combustion between the bridge wall and the back end of the tubes, as is characteristic of the horizontal return-tubular boiler. Horizontal space is as good as vertical, and all that was needed was air at the proper place. A good place to introduce it is at the back end of the grate or at the bridge wall.

Even with small space above the fire and small volume for combustion the best results can be obtained with proper firing and air properly admitted at the right point. This is proved by the Scotch boiler (in tests with which I am familiar), which is probably not excelled for economy, and has the steel surfaces with water on the other side of them closely surrounding the gases, there being small space above the middle of the fire and none at the sides. These surfaces do not cool the gases below the temperature of ignition, and in their travel from a point 16 in. in front of, to a point 16 in. back of, the bridge wall in this boiler, the gas will change from high CO to 15 per cent CO_2.

One object that I have in writing this letter is to check, if I can, the present mania for setting boilers high and the idea that there is more virtue in vertical volume than in horizontal. There is only one type of boiler that I can think of that may require a high setting, and that is the water-tube with transverse baffles. These boilers usually have a short path for the gases before they encounter the tubes, and in addition, as the streams of gas are substantially parallel, those having an excess of air are not able to mix with those having an excess of CO and other combustible gases. In addition to this the air that passes through the fire-door slides up the front header and has no chance to mix with the combustible gases. It only cools off the boiler. This was proved in the Emergency Fleet standard water-tube boiler, having longitudinal baffles, when we had the lower baffle a few inches away from the front header. We inserted a pipe so as to extract gas from points near the header and found the gas to be air, and a thermocouple in the same place showed the temperature of this air to be but little above that of the steam in the boiler.

In the case of the transverse-baffled boiler, raising it up may possibly enable the air that enters through the door to reach the combustible gases a little better than when set low, and a little good may be accomplished. The objections to such raising are that it adds to the cost of the setting and building and gives more opportunity for cracks. When stokers are applied, air that passes to the furnace through unfilled hoppers or the interstices in the coal, acts in exactly the same manner.

When boilers are set high, it is done as a gamble (seldom any reason being given for it) that air may enter somewhere where it will do some good by encountering combustible gases, and little or no attention is given to the chance that it will enter where it does no good and merely cools off the boiler.

It should be remembered that with large areas for gases to pass through, there is less prospect of the excess air in one place meeting the excess combustible gases in another, than when the area is small.

It is time that a halt was called on the practice of setting boilers high, except those with transverse baffles (if boilermakers will continue to baffle in this manner) and careful study be given to the matter in each application in connection with the proper admission of air. I know of a case where some boilers with longitudinal baffles have 8 ft. between the grates and tubes. These boilers are doing poorly, and the makers want to raise them still higher above the grates. This, of course, is folly. F. W. DEAN.

Boston, Mass.

INQUIRIES OF GENERAL INTEREST

Fire Cracks in Boiler Shells—What causes fire cracks in the shells of externally fired boilers? E. M.

Fire cracks in boiler sheets result from sudden cooling and contraction of the surface of the material when it is overheated. Hence, they are likely to occur at the outer edges of laps that are exposed to the intense heat of the fire and in parts of a boiler shell that become overheated from low water or the presence of such deposits as oil or scale on the interior acting as a non-conductor to prevent rapid absorption of heat by the water in the boiler.

Influence of Boiler Compounds on Engine Oils—What effect have boiler compounds on engine-lubricating oils? E. C. L.

Boiler compounds commonly contain soda ash, potash, caustic soda or other substances that have a deleterious effect on the lubricating qualities of cylinder oil by causing it to thicken when those substances are carried over in steam supplied to an engine. Trouble with crankcase oil for vertical steam engines may also result from excessive use of boiler compounds, by their being carried over to the cylinder and leaking out past the stuffing box to the crankcase, with formation of an emulsion.

Movement of Piston-Rod Gland in Stuffing Box—What causes the piston rod of our engine to carry the gland up and down in the stuffing box? H. B.

The gland would be moved by the piston rod if the crosshead guides are out of parallel with the cylinder center line or would be moved up and down if the crosshead shoes are not adjusted to obtain the right height of the crosshead for carrying the end of the piston rod in line. The trouble is probably due to want of correct adjustment of the shoes. If the gland is highest when the crank is nearest to the cylinder, the shoes should be adjusted to lower the crosshead, but if lowest with the crank nearest the cylinder, the shoes should be adjusted for raising the crosshead.

Low-Pressure Steam Gages—What is the difference between a low-pressure and high-pressure steam gage? P. W. W.

The designation "low-pressure" usually is applied to gages required for indicating 15 or less pounds per square inch. The principles of their construction and operation are the same as for gages to indicate higher pressures, but with greater sensitiveness of action. In the better Bourdon-type low-pressure gages the greater sensitiveness is obtained by employing a curved tube of thinner walls and broader proportion of cross-section, so the tube will move farther for small variations of pressure, rather than obtain sufficient movement of the pointer hand by means of mechanism that gives large multiplication of the small movement of a stiff gage tube, because there is corresponding multiplication of errors of movement of the pointer hand due to backlash of joints and other imperfections resulting from wear.

Transformer Regulation—In estimating the voltage drop in a feeder, what should be allowed for the drop in the transformer? R. J. E.

The full-load drop in a transformer is primarily a question of design. In transformers of one type, however, the drop will depend mainly on the capacity of the transformer and the power factor of the load, to a lesser extent on the voltage and the frequency. In general, the larger the transformer, the higher the power factor and the lower the frequency and the rated voltage, the smaller the voltage drop at full load. In average transformers at 80 per cent power factor, the drop will vary from about 7 per cent in 15-kva. 44,000-volt transformers to about 3.75 or 2.75 per cent in 11,000-volt transformers above 1,000 kva. At 100 per cent power factor, the drop will vary from about 2 to 3 per cent in 15 kva. 44,000-volt transformer to 0.8 or 0.6 per cent in 11,000-volt transformers larger than 1,000 kva.

Increasing Moisture of Steam for Manufacturing Process—For one of our factory processes it is desired to use wet steam at 80 lb. pressure. Can the required wetness be obtained by injecting boiling water into the live-steam line, or if not, what method could be employed? R. A. G.

Any degree of wetness can be obtained by injection of water through small openings so the water will be caught up and carried along with the steam as a spray. The pressure and temperature of the steam will be reduced unless the water is introduced at the same temperature as that of the steam. The operation would require a pump, or the injection of water can be performed by an injector that is supplied with water of lower temperature than the temperature of steam supplied to the injector. For obtaining wet steam with least reduction of pressure below the allowable boiler pressure and positive control of the amount of injection water, it would be a good plan to employ a small steam piston pump to perform the injection of hot water supplied direct from the boiler.

Use of Cinder Concrete in Compressor Foundation—Cannot a suitable foundation for an air compressor be made of cement and washed cinder in place of cement and gravel? L. J.

Concrete made of cinder is porous and therefore not suitable for a foundation exposed to frost and moisture. When made in proportions 1 of cement, 1 of clean sharp sand and 3 of washed cinder, or more thorough mixing in proportions of 1½ cement, 2 of sand and 4 of cinder, the strength is about one-half that of cement, sand and stone concrete, and the weight per cubic foot is about two-thirds as much. If cinder concrete is used, there should be a foundation bed of standard concrete at least 12 in. thick for anchorage of the foundation bolts, and for receiving the compressor, the upper surface of the foundation should be composed of a slab of standard concrete not less than 10 inches thick. The manufacturers of engines and of air compressors usually furnish the dimensions for standard concrete foundations which will possess a suitable amount of weight for stability in overcoming inertia of reciprocating parts, and to secure the same weight, any cinder concrete that is substituted should be 50 per cent greater in volume.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communication and for the inquiries to receive attention.—Editor.]

Spring Meeting A. S. M. E. at Chicago

AFTER a lapse of seventeen years Chicago again had the pleasure of entertaining the American Society of Mechanical Engineers at the spring meeting, held at the Congress Hotel from May 23 to 26 inclusive. Registration showed a record attendance of exceeding 1,200. An unusually full program had been provided and was taken care of nicely by simultaneous morning sessions. The afternoons were devoted to excursions to plants of interest and the evenings to special sessions or to general entertainment, which by special request was limited to the president's reception Monday evening and an informal dance Wednesday evening. Special sightseeing trips and other functions were arranged for the pleasure of the ladies in attendance.

In Chicago, Monday morning was devoted to registration and committee and council meetings. In the afternoon there was a business meeting at which President Carman presided. Morris L. Cooke presented an interesting paper "On the Organization of an Engineering Society," in which he pointed out the need for more democratic control of policies, more aggressive leadership in the execution of plans and, above all, an increase in activity of the individual member.

Gardner T. Voorhees presented a standard tonnage basis for refrigeration, which was adopted by the society. The standard ton of refrigeration is to be 288,000 B.t.u. and the standard commercial ton at the rate of 200 B.t.u. per minute. These approximate standards had been adopted previously by the American Society of Refrigeration Engineers. A committee progress report on standards for steel roller chains was presented and left open for discussion in *Mechanical Engineering*. One of the items of business creating much interest and discussion was the proposed revision of the constitution. Some changes were introduced by the committee, suggesting a regrading of membership and an increase in the dues, but primarily the object was to eliminate from the constitution all but the essential elements and transfer the balance to the by-laws, to make the conduct of business more flexible. The report of the Committee on Constitution and By-Laws, modified to conform with suggestions made at the spring meeting, will again be presented at the annual meeting in December and finally will be subject to a vote of the membership.

Tuesday Morning Sessions

On Tuesday morning there were four simultaneous sessions—on Fuel, Machine-Shop Practice, Management and General. The first and last are of particular interest to *Power* readers. With Joseph Harrington presiding, the Fuel Session was one of the best of the entire meeting. Valuable data relative to the burning of pulverized coal and the limitations of mechanical stokers were presented, the outstanding feature being the announcement of an efficiency over boiler and economizer of 90 per cent obtained at the Lakeside pulverized-coal plant of the Milwaukee Electric Railway and Light Co.

In the first paper of the session, "Recording Ashpit Loss from Chain-Grate Stokers," E. G. Bailey, the author, described a device recently developed to record the ashpit loss and make it possible for the fireman to control this factor. An abstract of this paper will appear in an early issue of *Power*.

Edward H. Tenney discussed the limitations imposed on mechanical stokers by the fuel, air supply and the design of furnace and the effect these limitations have on the operation of stokers of different types. One of the points made in comparing Mid-West coals, which are high in ash, moisture and volatile, with Eastern coals, was that the former requires about 2½ times as much furnace volume if like results are to be obtained at high ratings.

"Capacity and Efficiency Limitations of Stokers Using Mid-West Coals" was the subject allotted to John E. Wilson. Data from a number of chain-grate and underfeed stokers gave the average cost of repairs at 3.7 and 5.4c., respectively, per ton of coal burned. In the latter figure the cost of repair to fans and air ducts was included. With natural-draft chain-grate stokers the greatest loss from any two combined sources was from the chimney gases and carbon in the ash. Reducing these two losses afforded an opportunity for material gain. An interesting section of the paper was that covering the limitations governing the capacity of forced-draft chain-grate underfeed and overfeed stokers.

Dr. Vernon Hill, of the Bureau of Health for the city, spoke of the relation of smoke prevention to public health, which was considered of greater import than any other phase of the question. He failed to explain, however, why a purely engineering problem should be under the supervision of a commissioner of health rather than an engineer who, by his familiarity with all details of the work, should be able to contend more successfully with the problem and, by so doing, reduce the menace to health.

A paper by Frank Chambers on the latest requirements of Chicago in furnace design with special reference to hand-fired boilers was presented in abstract by Robert Kuss. It contained some interesting data on draft drop through the setting and in the gas passages, velocity of gas flow, area and height of stacks, city requirements and typical designs of furnace.

Boiler Tests with Pulverized Coal

"Boiler Tests with Pulverized Coal," by Henry Kreisinger and John Blizard was the paper on which the discussion centered. An abstract of this paper appeared in *Power*, May 31.

Following the paper some test results at the new Lakeside plant were given. Here there are eight boilers, each containing 13,060 sq.ft. of steam-making surface, a furnace volume of 7,200 cu.ft. and burning about 7 tons of coal per hour when operating at about 300 per cent of rating. In a 44-hour test at 138 per cent of rating, the thermal efficiency of the boiler alone was 83.42, and of boiler and economizer, 86.3 per cent. In a 24-hour test at 213 per cent of rating the efficiencies were 82.3 and 87.3, respectively; in a 20-hour test at 208 per cent of rating, 82.3 and 86.8, and in a 24.5-hour test at 136 per cent of rating, 85.6 and 90.2 per cent. In these figures no deductions have been made for auxiliaries. In the test, in which the 90.2 per cent efficiency was obtained, the CO_2 at the boiler uptake averaged 16 per cent and in the gases leaving the economizer, 13.2 per cent. The gas temperatures were 432 deg. leaving the boiler, 392 deg. entering the economizer and 205 deg. leaving the economizer. When operating at 208 per cent of rating, the gases left the boiler at a temperature of 484 deg., which was the lowest within the memory of the speaker.

In the discussion a boiler efficiency of 90 per cent was hailed as a record that should prove of the greatest economic importance and serve as a goal in the improvement of stoker operation. It meant a plant efficiency of 23 per cent and the production of a kilowatt-hour on 14,000 B.t.u. This was not the limit, as it was the opinion of Mr. Kreisinger that preheating the furnace air 180 deg. by steam from the lower stages of the turbine or some outside source would increase the efficiency of the boiler and economizer to 93 per cent. The flat efficiency curve over a wide range at Lakeside was emphasized. In the opinion of one of the speakers part of the gain in efficiency was due to the direct radiation from the flame. The higher initial cost of a powdered-coal plant was mentioned, but with the expected improvement in pulverizing and drying equipment, this cost would be reduced.

At the general session, with D. S. Jacobus as presiding officer, there were two papers, the first by Snowden B. Redfield on "Capacity Tests of Dry-Vacuum Pumps by the Low-Pressure Nozzle." Using a nozzle in which the back pressure is higher than the critical pressure permitted the determination of several values of volumetric efficiency over a wide range of vacua without changing the nozzle. Results were plotted in such a way as to furnish a graphic proof

of the accuracy of the theory of the nozzle and permit estimation of the performance of a given pump.

In the second paper Herbert B. Reynolds gave the test results on one of the 30,000-kw. turbines and its auxiliaries installed recently in the Fifty-ninth Street power station of the Interborough Rapid Transit Co., of New York. The best water rate obtained was 11.03 lb. per kw.-hr., the highest Rankine-cycle efficiency 75.5 per cent, and the highest thermal efficiency 25 per cent. One of the features of the installation described in the paper was the novel spring supports for the condenser, there being no expansion joint between the turbine and the condenser.

An evening session was devoted to "Training for the Industries," in which it seemed desirable that there should be a combination of the present methods of training in engineering schools and of the empirical methods used in the industries, based on experience and observation. Methods of bridging the gap between academic and practical training were proposed, and an outline was given of what the National Metal Trades Association is doing and intends to do in industrial education.

Wednesday Morning Session

On Wednesday at a simultaneous session presided over by Prof. C. Russ Richards, probably one of the most complete series of tests ever published on oxyacetylene welding and cutting blowpipes was presented, in a paper by R. S. Johnston. The general conclusions were that there was a great deal of difference between the characteristics of different designs of cutting blowpipes and that there was no make of apparatus that was equally proficient and economical for all thicknesses of metal. It was the author's opinion that the blowpipe designed to be free from flashback under all working conditions would be the safest blowpipe and the one which with ordinary care would produce sound welds. In such a blowpipe there would be maintained a one-to-one volume delivery of each gas at identical pressures.

J. R. McDermet emphasized the importance of taking into consideration the corrosive properties of a boiler-feed water as well as its scale-forming tendencies. Feed-water impurities fell into three groupings—dissolved solids (which may be either corrosive or scale-forming), pollution products and dissolved gases. Detection of each of these impurities was discussed as well as the effect of dissolved gases on the safe operating limits of hot-water feed lines, boilers and economizers with cast-iron or steel tubes. An appendix to the paper translated the facts presented into a working plan for use in the chemical laboratory.

"The Hydraucone Regainer, Its Development and Applications in Hydro-Electric Plants," was the subject of a most comprehensive paper by W. M. White, of the Allis-Chalmers Manufacturing Co. The device provides a means for recovering the energy discharged from the runner for useful effect on the waterwheel within the limited space available in power-house foundations. An abstract of this paper will appear in an early issue of *Power*.

In the discussion of the paper G. R. Shepard, of the Niagara Falls Power Co., gave the results of tests conducted on models of straight draft tubes, a straight tube flared at the end and fitted with a cone at the center, and a curved draft tube much flattened. These tests showed that for efficient operation some form of regainer is necessary. A spirited and extended discussion followed between adherents of the Moody design of draft tube and those defending the hydraucone regainer, the opposition claiming that the design of the latter was based on stream-line flow from the wheel and did not take into account the whirls introduced when the runner was in service. In the defense this contention was refuted. It was pointed out that the water could be deflected at right angles with slight loss and that the regainer could be installed in much less space than a straight expanding tube of great length.

A third session on Wednesday morning, with F. R. Low presiding, was given over to a public hearing and discussion of the power-test codes on General Instruction, Reciprocating Steam Engines and Evaporating Apparatus. The first two were adopted, and the code on evaporators was referred back to the committee to be considered in conference with a committee from the American Institute of Chemical Engineers.

Simultaneous Sessions, Thursday Morning

On Thursday morning there were simultaneous sessions on Railroad Locomotives, Materials Handling for Road Building, Forest Products and on Power. Samuel Insull, presiding officer, opened the Power Session with the remark that it took a great war and a British commission to convince this country that concentration in the production of electrical energy was an economic gain. The superpower plan proposed for the East was good and well-worth considering, but if engineers in general would pay more attention to the forwarding of similar projects in their respective localities, their efforts would be more effective. In the Mississippi Valley there were few locations where large plants could be located at the mouth of the mine because of lack of water. The plants must be at the centers of distribution, with no wasteful duplication, each serving the surrounding territory and all tied together by a network of transmission lines, where it can be done economically. The dominant factors in this territory, where relatively small water power is available, were cheap transportation and ample water facilities for condenser cooling and boiler feed.

Such a system, amplified by power from the mouth of the mine and by water power, would relieve the railroads of a part of their burden, hasten the day when they can be supplied with power more economically and make it possible to carry electrical energy to every village and even to the farms practically as cheap as at the large centers.

W. L. Abbott read an interesting paper on "The Location and Distribution of Central-Station Power of the Middle West." This section of the country contains only 18 per cent, or 776,000 kw. of the water power of the country, and the greater part of this lies in Michigan, Wisconsin and Minnesota. The states of Ohio, Indiana and Illinois, which are richest in coal, are poorest in water power. The author brought out the fact that it is cheaper to ship coal by rail to plants advantageously located than to generate at the mouth of the mine and have a stand-by station in the city with a transmission line between, this being true even with the excessive and unequal freight rates now in force. The distribution lines and the centers of power generation were shown, the largest center being Chicago and vicinity, with 500,000 kw., with Cleveland, St. Louis and Detroit following, each with a little more than 200,000 kw. The development of interconnection, first between small plants and then between groups or systems, developing slowly into the general scheme for generation and transmission, was traced by the author. A system covering an area equal to a state in extent and overlapping state lines under one management required state regulation. Subjecting a statewide industry of this charaeter to the vicissitudes and varying fortunes of local politics would not help the utility to develop and to most economically serve the various communities in question.

Future Development in Middle West

"Future Development in the Middle West," by C. W. Place, was the final paper of the session. The author pointed out that in this territory large centers of generation have been developed but they are far apart and each has its tributary country of low-load density made up of towns and villages and farming country drained by innumerable streams which should supply power to the towns and villages near them. In the fourteen Central States, the author said, there are 102 cities of over 25,000 people, each with a fairly efficient steam plant. It is proposed that the power houses of these cities be connected together, not by heavy high-voltage lines, but by lines which would pick up the small town and village load to the point where its next large neighbor would take its share. On the streams hydro-electric stations are to be developed which will automatically come on the line when needed and meet the demand temporarily, giving time before their pondage is exhausted to bring additional steam units on the line, although not necessitating that the boilers be maintained ready for immediate service.

Another suggestion that might prove feasible in certain localities was the pumping of water to an elevation during off-peak periods and allowing it to come down during the peak to develop the additional power needed.

In discussing the papers of the session, mention was made of the possibility of distilling the raw coal at the mouth of the mine, recovering the byproducts and using the gas in internal-combustion engines. In the case of long transmission lines from a hydraulic station the necessity of a full steam reserve was emphasized. In pumping water to an elevation to serve as a reserve, the crux of the question is the storage pond. If other than a natural pond be used, the expense would be prohibitory. Interconnection in Europe, where it was obligatory to draw on the most efficient station and use power from the less efficient stations only when their capacity was needed, while still protecting the investment in each station, received favorable comment, and it was suggested that in this country the Federated Engineering Societies should become interested in the consolidation and interchange of power. In closing the session, Mr. Insull outlined what has been done in the way of interconnection in Illinois and the surrounding states. To eliminate the promiscuous wasting of coal, no company should be allowed to generate power where it could buy it more cheaply. A state commission should have power to regulate, drastically if necessary, power generation along economic lines.

During the convention Atlanta was named as the city for the next spring meeting and the following nominations for officers were announced: President, Dexter S. Kimball, dean of engineering, Cornell University, Ithaca, N. Y. Vice presidents, Col. E. A. Deeds, president of Domestic Engineering Co., Dayton, Ohio; Robert Sibley, president of California McGraw-Hill Co., San Francisco, Cal.; L. E. Strothman, vice president and general manager of Richardson-Phœnix Co., Milwaukee. Managers, Sherwood T. Jeter, chief engineer of the Hartford Steam Boiler Inspection and Insurance Co., Horace P. Liversidge, assistant chief engineer of the Philadelphia Electric Co., Hollis P. Porter, superintendent of the Gypsy Oil Co., Tulsa, Okla.; to fill unexpired term of Dean Dexter S. Kimball, W. S. Finlay, Jr., American Water Works Association, New York City. Treasurer, William H. Wiley, president of John Wiley & Sons, New York City. Members of the American Engineering Council, Francis Blossom, of Sanderson & Porter, New York City; Charles A. Booth, vice president of Buffalo Forge Co.; Gano Dunn, president of J. G. White Engineering Corporation, New York City; H. H. Esselstyn, president of the Esselstyn, Murphy & Hanford Co., Detroit; W. S. Lee, chief engineer of the Southern Power Co., Charlotte, N. C.; Irving E. Moultrop, engineer of the Edison Electric Co., Boston; John A. Stevens, consulting engineer, Lowell, Mass.; A. E. Walden, chief engineer of the Baltimore County Water and Electric Co.; Perley T. Walker, dean of engineering, University of Kansas, Lawrence, Kan.

Refrigerating Engineers Meet in Chicago

From May 25 to 27 inclusive the American Society of Refrigerating Engineers held its eighth Western meeting in Chicago, with headquarters at Hotel Drake. The attendance was excellent for a spring meeting, and a number of interesting papers appeared on the program. Wednesday morning was taken up largely by routine business, H. C. Gardner, vice president, acting as chairman in the absence of Fred Ophuls, president of the society. The usual presidential address was read by Mr. Gardner.

One of the first topics brought up for discussion at the afternoon session was the revised refrigeration code. Several exceptions were taken to the code in its present form. One dealt with the pressure at which the release devices for different refrigerating mediums should be set. If the pressure given for an ammonia system was correct, the pressures listed for ethyl chloride, sulphur dioxide and methyl chloride were too high and should be reduced to correspond with the pressure given for ammonia. In other tabulations throughout the code the same line of reasoning was to be applied. Several members could not see the necessity of isolating the refrigeration equipment from the electrical equipment, as required in the code, and it was agreed that the lower limit of three tons as the size of a plant requiring a licensed engineer was unreasonable. This figure should be raised to 20 or 30 tons and above.

In a paper on "Modern Propeller Design for Brine Agitation and Circulation," E. A. Burrows described a type of propeller he had constructed in accordance with formulas developed by O. G. Halvorsen, professor in marine engineering at the technical college at Trondhjem, Norway. Under such conditions a 12-in. propeller at 700 r.p.m. had developed a capacity of 3,240 gal. per min. with a hydraulic efficiency of 87.5 per cent, requiring 3.4 b.hp. to drive it. The gallons circulated increased with the speed, but the hydraulic efficiency decreased, until at 1,800 r.p.m. it reached 66.2 per cent when circulating 8,830 gal. per min. and requiring 18.5 b.hp. Methods of developing the propeller were described and mention made of a small propeller 3 in. in diameter suitable for mounting directly in a brine circulating pipe which had moved brine at the rate of 6 gal. per min. against a total head of 15 ft. when driven at 2,000 r.p.m. Experiments made by the author on 3-, 8-, and 20-in. propellers, designed according to Professor Halvorsen's formula, indicated a reduction in power consumption of from 25 to 50 per cent as compared with the ordinary type of brine propeller.

Multiple Effect Compression

H. C. White, of the Consumers Co., Chicago, presented a brief paper on "Mutiple Effect Compression," several machines of the company having been equipped with the Voorhees devices. The method consists in first filling the compressor cylinder with low-pressure gas; then near the end of the stroke switching over the valves and admitting gas at higher pressure to compress the charge and fill the cylinder with denser gas. This is possible in a plant where the work is split up between high- and low-pressure systems and results in a considerable gain in economy. Mr. White gave test data on a single-acting compressor with a condenser pressure of 185 lb. and suction pressures of 20 lb. gage and 35 lb. gage. In the first case it was necessary to compress 4.17 cu.ft. of gas per ton of refrigeration with a compression horsepower of 1.336. In the second case 2.84 cu.ft. was compressed with a horsepower of 0.98. Thus with the 35-lb. suction pressure, 47.5 per cent more capacity was obtained and 26.5 per cent less power per ton of refrigeration. For each pound increase in suction pressure the saving was placed at 1.76 per cent.

Comparative tests on another unit equipped with the Voorhees devices, with 20-lb. suction pressure and then 35-lb. suction pressure, each test continuing for six days, showed 35.2 per cent more ice for the higher suction pressure and the consumption of 12 per cent less power per unit. At the lower suction pressure and a speed of 72 r.p.m., the power requirement was 59.5 kw.-hr. per ton of ice. At the higher suction pressure, 35 lb., and a speed of 60 r.p.m., 52.3 kw.-hr. was required per ton. The conditions generally, with the exception of the speed, were practically the same in the two tests. It should be mentioned that the compressor was motor-driven, and if steam-driven the gain in economy would be still greater, as the engine would be more economically loaded and the better water rate obtained on this account would be added to the saving made in the compressor.

A paper on "Spray Cooling Systems," by P. K. Lindsay, and read by O. J. West, brought out the great increase in cooling capacity obtained by the use of sprays, over a basin or pond without the sprays, indicated the piping arrangement used and the operating pressure, described the nozzles and summarized the average cooling results from a well-designed spray system with unrestricted air circulation.

On Thursday morning E. F. Mueller gave a progress report of the Bureau of Standards work on anhydrous ammonia tables. It will be remembered that the society has been furnishing sufficient funds to employ two research men on this work at Washington, and that eventually it is the intention to prepare tables for CO_2 and other refrigerants. By next year it was thought that the ammonia tables

would be finished and that some progress would have been made on the CO_2 data. In the meantime it was necessary for the society to furnish $6,000 to continue the work until the Government could be induced to appropriate sufficient funds to carry on the work and thus relieve the society of further expense. The value of the work had become so apparent that little difficulty was anticipated in securing a Government appropriation.

"Arc Welding Applied to Refrigerating Machinery," by A. M. Candy, and "Tests on Welded Containers," by Prof. E. A. Fessenden, were two papers received with much interest. The first-named pointed out how arc welding apparatus could be used to advantage for repairing a large variety of defective or accidentally damaged shop or plant machinery, and also covered some of the underlying fundamental welding principles, including proper methods of arc-welding process control and methods of visual inspection which permit of commercially accurate evaluation of arc welded joints. It was the author's conclusion that if manufacturers of refrigerating machinery would develop the arc welding process by actual experimentation in their plant, following all of the data and principles mentioned in the paper, arc welding could be economically and effectively applied in many operations where it is now thought to be impracticable.

The second paper gave the results of a series of tests on welded ammonia containers involving the following four types of construction: (1) Flange steel shell, acetylene-welded longitudinal seam, concave heads welded to shell; (2) seamless pipe shell, convex heads acetylene-welded to shell; (3) seamless pipe shell, concave heads forge welded to shell; (4) flange steel shell, acetylene-welded longitudinal seam, convex heads acetylene-welded to shell. The author outlined the method of conducting the tests, gave the results and drew the conclusion that vessels having forge-welded seams were the least desirable. The tests also indicated that the acetylene welds were likely to have occasional porous spots and that pinholes might often develop when high pressures were reached. Welds joining fittings for pipe connections to the vessel were almost as likely to cause failure as the longitudinal and circumferential seams. In acetylene welds the principal defects seemed to be the coarse granular structure and porous spots obtained and the occasional poor adhesion of the welding material to the original plate.

Refrigeration in Rubber Manufacture

In a paper on "Refrigeration in the Manufacture of Rubber," J. H. Vance outlined first the manufacturing process consisting of washing, drying and mixing the rubber. Refrigeration was required principally for cooling the water used to keep the mixing rolls at a temperature below that which would scorch the rubber. A water-inlet temperature to the mixing rolls of 58 deg. F. and an outlet temperature of 65 deg. F. allowed a suction pressure of 45 lb. gage for the compressor. It was usual to allow one-sixth ton of refrigeration per lineal inch of width of the rolls, but it was desirable for the manufacturer, when figuring capacity, to take into account the quantity of water to be handled and the temperature range.

At the Thursday afternoon session, S. C. Bloom discussed "Brine Spray Refrigeration," comparing a new type of nozzle which gave a hollow cone-shaped spray with the earlier inefficient devices giving a coarse flat spray. One of the earlier methods was to use a plugged nipple discharging against a plate or an adjustable nozzle which the operator could change at will. In the older systems pressures ranged from 20 to 70 lb., although 25 lb. would have been sufficient for most cases. Spaces between nozzles varied from 12 to 48 in. according to the whim of the designers. The mains were connected in parallel so that a reduction of pressure on one would affect all. With a direct-acting pump controlled by a governor, this would not be detrimental, but not so when the drive was a constant-speed turbine or motor. Brine temperatures employed ranged from 8 to 20 deg. F., and the height from deck to ceiling averaged from six to eight feet. Besides, it was commonly thought that the stronger the brine solution the better would be the results.

Improvements in the deck system of spraying had been sought by the author and applied quite extensively in the Chicago plants of Armour & Co. A weak brine solution is employed and the problem was to secure better circulation and more rapid cooling. Nozzles were used in which the spray formed in the shape of a hollow cone, and they were spaced so that the cones of spray intermixed and filled the entire space of the cooler loft. The most suitable pressure was found to be 7½ lb. Gravity tanks were arranged above the nozzles to prevent variation in pressure, and this, coupled with non-adjustable nozzles, made a system practically foolproof. Comparative data giving operating characteristics and costs on flat and cone-shaped sprays with varying quantities of brine were presented by the author and showed much in favor of the latter type of nozzle. In these modern installations it was attempted to present as much brine surface as possible to the air, secure rapid circulation of air through the brine and proper spacing of nozzles, and with the brine system obtain concentration of the ammonia at the power house. A number of interesting slides showing the Armour installations were thrown on the screen.

In a paper on "Modern Air Compressor Practice and Testing," Harry Feldbush outlined the usual methods of testing high-speed air compressors belt-driven by motor, direct-connected or steam-driven. In measuring the air, the low-pressure orifice was preferred to the high-pressure orifice, as it was more efficient and made less noise. The various efficiencies it was necessary to obtain were defined, and curves were presented to facilitate the computation of test data.

Other papers of this final session were "Water Treatment for Raw Water Ice," by John J. Felsecker, and "Eggshell Sterilization for Cold Storage," by Elmer Anderson. Placing the eggs in a hot-oil bath before storage so sealed the shell that the egg was impervious to surrounding odors and would retain its freshness for months.

On Thursday evening there was a banquet at Hotel Drake, and Friday was given over to inspection trips to points of interest about the city.

Annual Convention International Railway Fuel Association

From May 24 to 26 inclusive the International Railway Fuel Association held its thirteenth annual convention in Chicago, headquarters being at the Hotel Sherman. There was a good attendance, and lively interest in the proceedings was indicated by extended discussion on the various topics presented before the convention. There were a number of interesting committee reports on briquets and subnormal fuels, fuel accounting, pulverized fuel, locomotive feed-water heating and the storage of coal. The official papers presented were diversified in character including discussion on the following topics: Fuel department organization, the value of an individual fuel-performance record, oil shale as a source of oil supply, separation and distribution of fuel, standards of fuel-economy practice, a few essentials of fuel economy, fuel conditions on French railways, and other duties of a fuel inspector.

Officers elected for the ensuing year are: W. L. Robinson, president; W. J. Bohan, J. N. Clark and M. A. Daly, vice presidents; J. G. Crawford, secretary and treasurer. On the executive committee, J. B. Hurley was elected for three years; for two years, A. P. Bentley, D. I. Bergin, C. M. Butler, Joseph Keller and Hugh McVeagh; for one year, Philip E. Bast, Robert Collett, J. W. Dodge, J. M. Nicholson, and T. Duff Smith.

The value of the steam and gas engines and water turbines manufactured in the United States in 1919 was $464,909,000, as compared with but $72,121,000 in 1914, according to the preliminary statement of the 1920 United States Census of Manufactures. The value of electrical machinery, apparatus and supplies increased from $335,-170,000 in 1914 to $884,343,000 and of steam and other power pumps from $17,864,000 to $53,716,000.

Washington News

Frelinghuysen Bill Called Unconstitutional—House Passes Hoover's Appropriation—Completion of Wilson Dam Strongly Urged by Farm Bureau

By Paul Wooton
Washington Correspondent

Any law providing for compulsory collection of production statistics is distinctly beyond the power of Congress and clearly unconstitutional, according to an opinion rendered by Nathan B. Williams, counsel for the National Manufacturers Association, in connection with the Frelinghuysen bill providing for compulsory fact-finding as to coal production. Mr. Williams stated that it has been held repeatedly by the Supreme Court of the United States that, under the commerce clause of the Constitution, Congress has no control whatever over production, as "production" is not "commerce." He cited a number of opinions to sustain this contention.

L. Ert Slack, special assistant to the Attorney General, has filed his brief with the Supreme Court of the District of Columbia in the injunction proceedings brought by the National Coal Association. Mr. Slack developed in detail the arguments that he made orally at the time the case was heard. Counsel for the National Coal Association is completing the brief that will be presented in behalf of the association.

The Calder committee on reconstruction and production, in its final report, stated that it had abandoned the idea of Government control of coal and recommended in its stead legislation providing for the securing, collecting and publishing of information and statistics with respect to the coal business.

Hoover's Estimates Approved

While it took a special rule to do it, the House of Representatives has approved Secretary Hoover's supplemental estimates for the Department of Commerce, recommended by the Committee on Appropriations, for extending the export trade; for investigating structural material; for assisting in the establishing of industries developed by the war and for standardizing electrical and mechanical devices used in industries. The opposition to the items was entirely on political grounds on the plea that the real object of these appropriations was to create positions for the faithful. This attack did not have the backing of the Democratic leaders, however, and the items were approved.

The fight on the $250,000 for the Bureau of Standards was even more intense than was that on the $250,000 for promoting export trade. A fillibuster was attempted against the items, but was overridden by the bringing in of a special rule, making the items in order. In supporting the Bureau of Standards items, Chairman Good said: "We have placed in the Department of Commerce one of the greatest engineers, one of the greatest manufacturers in America and we are going to support him."

Farm Bureau Federation Reports

The recommendations of the special committee of the American Farm Bureau Federation are that the Wilson Dam, located at Muscle Shoals, be completed by the Government without continued delay and that the air-fixation nitrate plants be placed under the direction of a governmentally owned corporation. This corporation may, in its discretion, operate the plants or maintain them ready for operation, but with strict regulations relative to prices to be secured for commodities in which the products of these plants are used. These recommendations have been approved unanimously by the executive committee of the Farm Bureau Federation.

The Wilson Dam, which was started during the war, is about one-third completed. Two nitrate manufacturing plants have been erected within a short distance of the dam and also a big steam-power plant. During the war one of these nitrate plants was operated very successfully, the power being furnished by steam.

The committee reports that only the work of maintenance is now being done at the Wilson Dam and that this charge is too great to be continued long. The work cannot be resumed until Congress makes an appropriation of approximately $10,000,000, and the dam is indispensable to a successful and economical operation of the nitrate plants. The Federal Government has invested millions of dollars at Muscle Shoals, and the committee feels that it is good business to complete the investment by finishing the dam and operating the plants. The report in part says:

Nitrate Plant No. 1, Nitrate Plant No. 2 and the Wilson Dam together constitute what is probably the greatest single conservation activity of our Government. This entire project should be viewed in the same light as is an irrigation project, a forest reclamation activity or a levee and drainage problem. Its great purpose, in peace times, is to assist in maintaining our soil fertility and consequently in the adequate production of food for our increasing millions.

With the immense water-power development incident to the completion of the Wilson Dam, there is the certainty that much of the electrical power can be sold for industrial uses other than operating Nitrate Plant No. 2. Within easy transmission distances of Muscle Shoals lie the metropolitan centers of Birmingham, Alabama; Memphis, Tennessee; and Chattanooga, Tennessee, not to mention others of considerable importance. The great coal operations of this territory may be expected to become users of electric current, too.

The Chief of Engineers has been instructed by the Secretary of War to ascertain if any power companies would be interested in entering into a contract with the Government to take over power which would be generated at Muscle Shoals in case the dam were completed. Secretary Weeks is anxious to get in definite form any proposition from private interests as to the disposal of this power.

Heating and Ventilating Engineers To Meet in Cleveland

"Byproduct Coke Ovens and Their Relation to Our Fuel Supply" is one of the important papers scheduled for the semi-annual meeting of the American Society of Heating and Ventilating Engineers, which is to be held at Cleveland, June 14-17. The complete program follows:

Tuesday, June 14, 2 p.m.—Welcome address; response by president; annual reports of chapters; reports of the committee on chapters and of the committees on a code for testing heating systems, on a code for testing low-pressure heating boilers, on increase of membership, on a model chimney ordinance and on the revision of the constitution.

Wednesday, June 15, 9 a.m.—Air Conditioning Session: "Resistance of Materials to the Flow of Air," by A. E. Stacey, Jr.; "Drying as an Air-Conditioning Problem," by A. W. Lissauer; "Rates of Drying," by Ray Power, United States Department of Agriculture.

Thursday, June 16, 10 a.m.—Heating Session: "Byproduct Coke Ovens and Their Relation to Our Fuel Supply," by E. B. Elliott; "Hot-Water Heating in Asia Bank," by H. L. Alt; "Circulation Problems in Hot-Water Heating," by A. W. Luck; "Fractional Distribution in Two-Pipe Gravity Steam-Heating Systems," by J. A. Donnelly; "The Application of Gas to Space Heating," by Thompson King.

Thursday, June 16, 2 p.m.—Ventilation Session: "Some Developments in Centrifugal Fan Design," by F. W. Bailey and A. A. Criqui; "Plea for Better Distribution in Ventilation," by J. R. McColl; "Ventilation in Metal Mines," by D. Harrington, United States Bureau of Mines.

Friday, June 17, 10 a.m.—Research Session: Report of committee on research; "Apparatus for Testing Insulating Materials," by F. B. Rowley; "Ventilation Tests of Schoolrooms at Minneapolis," by L. A. Scipio; "Chimneys for House-Heating Boilers," by L. A. Scipio; "Dust Standards," by S. H. Katz; Commentary by L. A. Scipio on the Report on Heat Transmission, Corkboard and Air Spaces by A. J. Wood and E. F. Grundhofer.

Headquarters will be at the Hotel Winton. Arrangements have been made for the entertainment of ladies, and there will be dances, theater parties, excursions, bathing and other diversions to round out the stay of visitors to the convention. The secretary of the society is Casin W. Obert, who may be reached at the national headquarters of the society, the Engineering Societies Building, 29 West Thirty-ninth Street, New York City.

New Publications

ELECTRICAL MACHINERY. A Practical Study Course on Installation, Operation and Maintenance. By F. A. Annett, associate editor of *Power*. Published by the McGraw-Hill Book Co., Inc., New York, 1921. Semi-flexible, 5 x 8 in.; 431 pages; 491 illustrations; 11 tables. Price $3.

Essentially a practical book, dealing with different phases of every-day electrical engineering practice in the simplest possible way, the 28 chapters cover the following subjects: Fundamental principles; elementary magnetism; fundamentals of the electric circuit; Ohm's law; energy, work and power; complex circuits and effects of internal resistance; electrical instruments; calculating size of conductor; fundamental principles of dynamo-electric machinery; direct-current machinery construction; inductance and commutation; types of direct-current generators; direct-current generator characteristics; losses in direct-current machinery; direct-current motors; types of direct-current motors; starting rheostats and connections to direct-current motors; three-wire systems and how they may be obtained; direct-current generators in parallel; fundamental principles of alternating current; measurement and addition of alternating voltages and current; two-phase and three-phase circuits; operating alternators in parallel; kilowatts, kilovolt-amperes and power factor; potential and current transformers; alternating-current motors; starting polyphase motors.

The author has made an exceptionally extensive use of mechanical and hydraulic analogies and these, together with the large number of good illustrations, help to make this an ideal book for beginners. The pictures tell half the story before the student starts to read the text. Simplicity and clearness are the outstanding characteristics of the language, and mathematics have been carefully avoided throughout. The whole treatment of the subject can be traced directly to the author's long experience in teaching electricity to practical men. Though simple in treatment, the book can by no means be classed as elementary in subject matter. The very thorough treatment of all the problems of installation, operation and maintenance of electric systems and equipment, together with the large number of wiring diagrams of apparatus, make it a valuable reference book for any engineer's shelf. Aside from this, the responsible engineer's work is today taking on an educational tinge, for in the elaborate modern systems no engineer can afford to leave his subordinates in ignorance of what they are doing. But it is one thing to know and quite another to explain and make clear to others, and the author's ingenious analogies will simplify this for a great many men.

HEAT TRANSMISSION

Bulletin No. 30 of the Pennsylvania State College, State College, Pa., contains a good deal of valuable material on the subject "Heat Transmission—Corkboard and Air Spaces." It was prepared by Arthur J. Wood, professor of railroad mechanical engineering, and E. F. Grundhofer, instructor in experimental engineering. The bulletin constitutes a report of work done at the thermal testing plant of the College, describing in detail a series of tests on the Postal test box and on a new cubical box recently developed. The general process of heat transmission is also covered.

Personals

J. B. Crane, formerly with the Binghamton, (N. Y.) Light, Heat and Power Co. as construction superintendent, has become associated with the George T. Ladd Co., of Pittsburgh, Pa.

Millard C. Ernsberger, professor of mechanical engineering in the University of Rochester, has been appointed professor of power engineering in the Sibley College of Mechanical Engineering at Cornell University.

Albert J. Albrecht, formerly draftsman in the artillery drawing room of Midvale Steel and Ordnance Co., is now draftsman in the engine drawing room of Wm. Cramp & Sons Ship and Engine Building Co., Philadelphia, Pa.

Business Items

The Moloch Stoker Co., of Chicago, has been consolidated with the Kaukauna Machine Works, of Kaukauna, under the name of Moloch Co., with offices and factories at Kaukauna, Wis.

The Tucker-Day Machinery and Supply Co., 619 National Building, Cleveland, Ohio, has been formed by George Day, formerly sales manager of M. Beatty & Sons, of Welland, Ontario, and D. S. Tucker, district sales manager of the Elliott Co., of Pittsburgh. The new firm will specialize in drop forgings, general contracting and power plant equipment.

Trade Catalogs

The George J. Hagan Co., People's Bank Building, Pittsburgh, Pa., has issued an 18-page bulletin on its line of liquid fuel burners for steam generation. Layouts are shown of the application of these burners to different boilers.

The Oleite Corporation., 110 William St., New York City, has prepared two bulletins, E and F, on the filtration of water for domestic and industrial use. Bulletin E deals with the "Deoleizer," in which "Oleite," described as "a powerful organic absorbent and decolorizing agent," is used with sand to purify water for boiler feed and many other purposes. Bulletin F deals with the use of the "Deoleizer" in the ice plant.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	May 24 1921	May 31 1921
Pocahontas,	Columbus	$3.50	$3.50
Clearfield,	Boston	2.40	1.85@2.80
Somerset,	Boston	2.90	2.60@3.25
Pittsburgh,	Pittsburgh	2.10	1.85@2.00
Kanawha,	Columbus	2.65	2.25
Hocking,	Columbus	2.40	2.25
Pittsburgh No. 8	Cleveland	2.25	2.15@2.35
Franklin, Ill.,	Chicago	3.15	2.50@3.50
Central, Ill.,	Chicago	2.60	2.00@2.75
Ird. 4th vein,	Chicago	3.10	2.50@3.25
Standard,	St. Louis	1.75	1.75
West Ky.,	Louisville	2.20	1.90@2.25
Big Seam,	Birmingham	2.95	2.85@3.10
S. E. Ky.,	Louisville	2.60	2.25@2.50

DIESEL FUEL OIL

New York—On June 1, Port Arthur light oil, 23@25 deg. Baumé, 4¼c. per gal. 30@35 deg., 6c. per gal. f.o.b Bayonne, N. Y.

Chicago—May 28, for 24@28 deg Baumé, 55@55c. per bbl.; 32@34 deg., 2@2¼c. per gal. In tank cars f.o.b. Oklahoma refinery, or freight adjusted.

St. Louis—May 28, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 65c. per bbl.; 26@28 deg., 70c.; 28@30 deg., 80c.; 32@34 deg., 3c. per gal.

Baltimore—On April 23, f.o.b. refinery; in tank-car lots; 24+ deg. Baumé, 6¼c.; 26@28 deg., 6¾c.; 30@34 deg., 7⅜c.; 14+ deg., $1.95 per bbl.; 16@20 deg., $1.85 per bbl.

Pittsburgh—On May 31, f.o.b. refinery; Pennsylvania, 36@40 deg., 4c. per gal.; Oklahoma, 24@30 deg., 50c. gas oil, 32@34 deg., 2c. per bbl., 36@38 deg., 2¼c. 38@40 deg. 2½c.

Philadelphia—On April 12; 26@28 deg. Baumé, Oklahoma, 85c. per bbl.; 30@34 deg., Oklahoma (group 3), 3c. per gal.; 16@20 deg., Seaboard, 5c. per gal.

Cincinnati—May 28, for 22@28 deg. Baumé, 6⅝c. per gal.

Cleveland—May 28, for 22@28 deg. Baumé, 5¼c. per gal.

New Construction

PROPOSED WORK

Mass., Boston—Snyder & Druker, 18 Tremont St., are having plans prepared for an 8 story office building on Oliver St. G. N. Jacobs, 9 Hamilton Pl., Archt.

Conn., Fairfield—The Porcupine Co., Wordin Ave., Bridgeport, plans to build a 1 story plant on Boston Post Rd., here, to be first unit of large boiler plant. About $50,000.

Conn., Hartford—The High School Plant and Bldg. Comn. plans to build a 3 story, high school on Ridgefield and Greenfield Sts. About $1,500,000. W. H. Seaville, Comn. Chn. F. I. Cooper Corp., 33 Cornhill St., Boston, Mass., Archt. L. W. Robinson, 42 Church St., New Haven, Consult. Engr.

Conn., Meriden—S. Z. Poli Co., 24 Church St., New Haven, plans to build a 1 story theatre on West Main St., here. About $500,000.

N. Y., New York—(Brooklyn Boro) The Brooklyn Edison Co., 360 Pearl St., plans to build a power plant on Marshall St. About $750,000. G. L. Knight, Archt. and Engr.

N. Y., New York—(Manhattan Boro) The Dept. of Health, 505 Pearl St., received bids for furnishing, delivering and installing (A) one additional boiler and (B) relocating one present boiler in the power house at North Brothers Island from Almirall & Co. Inc., 1 Dominick St., (A) $25,937 (B) $22,616; Shevlin Eng. Co., 110 West 34th St., (A) $24,652 (B) $22,048; Austin Eng. Co., 121 West 42nd St., (A) $27,772 (B) $24,372. Noted May 23.

Pa., Philadelphia—The Bd. Educ., 18th and Chestnut Sts., will receive bids until June 9 for a 3 story, 146 x 170 ft. public school including a steam heating system on 7th and Norris Sts. About $650,000.

Pa., Philadelphia—The city will receive bids until June 10 for a 60 in. pumping main.

W. Va., Ceredo—The Bd. Educ. has awarded the contract for installing a furnace blast system in the high school here to the Columbus Heating and ventilating Co., 34 Wise and Smith Bldg., Charleston.

W. Va., Huntington—The Main Island Creek Coal Co., Holden, plans to build a 25 story office building on 9th St. About $1,000,000.

N. C., Charlotte—The Oklahoma Asphalt & Ref. Co., 219 West First St., is in the market for a 500 hp. boiler, one 3 in. water pump, etc. J. T. Paschal, Secy. & Mgr.

Fla., Miami—The First Natl. Bank will receive bids until June 15 for a 4 to 12 story office and bank building. About $500,000.

Fla., Orlando—H. Hand and Associates had plans prepared for an 8 story, 150 x 185 ft. apartment hotel including a steam heating system and ice plant, on Orange Ave. About $400,000.

Ala., Carson—J. R. Wallace is in the market for two 72 x 18 H. R. T. boilers or equivalent in water tube boilers and engine that will develop not less than 150 hp.

La., New Orleans—The Sewerage Water Bd. will receive bids until June 21 for furnishing and constructing a 200 hp. fuel oil engine.

O., Cleveland—The City received bids for installing plumbing, heating and ventilating systems in the proposed hospital buildings from Warden & Lees Co., 2450 Prospect Ave., $459,345; W. G. Cornell Co., Leader News Bldg., $529,199; Smith & Obey, Carnegie Ave., $591,000. Noted May 23.

Mich., Detroit—The Pub. Lighting Comn., 138 East Atwater St., plans to build an electric power plant at 24th St., along the Detroit River. The plant will be equipped with two 20,000 kw. steam driven dynamos with provision for ultimate equipment for a 120,000 kw. output. About $5,000,000. Frank Mistersky, Supt. Smith, Hinchman & Grylls, 710 Washington Arcade, Engrs.

Mich., East Lansing—A. M. Brown, Secy. of the State Bd. of Agriculture will receive bids until June 14 for a 1 story boiler house for the Michigan Agricultural College. About $75,000.

Mich., Grand Rapids—The Fountain St. Baptist Church, plans to build a 1 story church on Fountain St. About $500,000. Coolidge & Hodgson, 134 South LaSalle St., Chicago, Ill., Archts.

Mich., Saginaw—Schmidt Garden & Martin, Archts., 104 South Michigan Ave., Chicago, Ill., will soon award the contract for a 4 and 5 story, 50 x 90 ft. addition to

hospital on Harrison St., for the Saginaw Genl. Hospital Assn. An addition to the present steam heating system will be installed in same. About $600,000.

Ill., Chicago—H. Emmerman, c/o Fugard & Knapp, Archts., 64 East Van Buren St., plans to build a 1 story theatre on Sheridan Rd. and Lawrence Ave., to cost about $500,000 and a 15 story, 125 x 175 ft. store and office building at 4750 Sheridan Rd., to cost about $2,000,000. A steam heating system will be installed in each.

Ill., Chicago—Graham, Anderson Probst & White, Archts., 80 East Jackson St., will soon award the contract for a 20 story, 178 x 315 ft. bank and office building including a high pressure steam heating system on Jackson and Clark Sts., for the Illinois Merchants Trust Co., 112 West Adams St. About $9,000,000.

Ill., Joliet—The Bd. Educ. will soon award the contract for a 2 story school including a steam heating system. About $300,000. J. F. Skeel, Liberty Bldg., Clk. D. H. Burham & Co., 209 South LaSalle St., Chicago, Archt.

Ia., Griswold—The city plans an election to vote on $50,000 bonds to build and equip a light and power plant.

Minn., Minneapolis—The Federal Reserve Bank, 9th Dist., is having plans prepared for a bank including a steam heating system on Marquette Ave. between 5th and 6th Sts. About $350,000. Cass Gilbert, 244 Madison Ave., New York City. Archt. Cunwald Aus. 244 Madison Ave., New York City, Engr.

Minn., Minneapolis—The Northwestern Natl. Bank, Marquette Ave. near 4th St., is having plans prepared for a bank building on Marquette Ave., and 6th St. About $400,000. Cass Gilbert, 244 Madison Ave., New York City, Archt.

Kan., Arkansas City—T. Williamson & Co., Archt. 321 Central Natl. Bank Bldg., will receive bids until June 25 for a 2 story high school for the Bd. Educ. About $250,000. C. E. St. John, Supt.

Kan., Lawrence—The State Bd. of Administration, Topeka, will receive bids until June 21 for a 2 story power house, here. About $100,000. R. L. Gamble, 1415 Fillmore St., Topeka, Archt. Noted May 3.

S. D., Beresford—The city has authorized $70,000 bonds for improvements including a new well at the waterworks plant and an engine for electric plant.

S. D., Brookings—The city will receive bids until June 14 for a boiler and equipment for power plant.

N. D., Devils Lake—The Bd. Educ. plans to build a 2 or 3 story, high school, including a steam heating system, etc. About $325,000. Nelson Sauvain, Supt of Schools.

Mont., Billings—The Merchants Natl Bank is having plans prepared for an 8 story, 75 x 125 ft. bank and office building including a steam heating system. About $500,000. Weary & Alford 1732 South Michigan Ave., Chicago Ill., Archts.

Mo., Chillicothe—The Secy. of the Bd. of Pub. Wks., will receive bids until June 10 for an addition to power plant and a 7 x 13½ ft. addition to engine room building, also for furnishing and constructing a one 500 kw. generator with exciter direct connected to condensing steam engine or turbine, superheater in two 150 hp. return tubular boilers with alternate bid on equipment for 4 boilers, one switch board panel for generator unit, one Venturi meter with recording mechanism, one boiler feed hot water meter, E. E. Harper, Kansas City, Mo., Engr.

Mo., St. Joseph—The Methodist Hospital Association will receive bids until June 15 for a 5 story, 120 x 180 ft. H shape hospital. About $650,000. Eckel & Aldrich, Archts.

Mo., St. Louis—The Standard Underground Cable Co., Westinghouse Bldg., Pittsburgh, Pa., plans to build a manufacturing plant on Kingshighway and Slevin Ave. About $1,000,000. Architect not yet selected.

Okla., Amorita—The cities of Kiowa, Kan., and Bryon, Okla., plan to vote $15,000 bonds each for a transmission line from here to Kiowa and from Kiowa to Bryon. W. B. Rollins Eng. Co., Kansas City, Mo.

Okla., Sayre—The city plans an election June 14 to vote on $28,500 bonds for a watermain extension including a reservior pumping equipment, etc. and $20,000 bonds for an electric power station. V. V. Long & Co., 1300 Colcord Bldg., Oklahoma City, Engr.

Col., Denver—The State Bd. of Regents, University of Colorado, Boulder, has engaged Biscoe, Fisher & Fisher, Archts., United States Natl. Bank Bldg., Denver, to prepare plans for a group of buildings for state hospital and medical school here. About $1,500,000.

Que., Montreal—The Cement Products Co., 9 Drake St., is in the market for one 5 hp. and one 25 hp. electric motors.

Que., Montreal—The city will receive bids until July 15 for additions to plant and installation of 6 electrical pumps to have a 30,000,000 gal. capacity, and changing large pump from steam turbine driven to electrically driven. About $800,000. A. E. Doucet, City Hall, Engr.

Que., Montreal—The Fire Proof Crushed Stone Co. Inc., 2650 Masson St., is in the market for an electric motor, etc.

Que., Napierville—A. Beaulieu, Secy and Treas., will receive bids until June 11 for a transmission line from here to Laprairie for the Compagnie d' Eclairage de Napierville. About $59,000. A. Roy, 502 St. Catharine St., East, Montreal, Engr.

Ont., Sault Ste. Marie—The Bd. Educ. had plans prepared for a 2 story technical school including a steam heating and ventilating system. About $350,000. J. T. Later, Secy. Findlay & Faulis, 529 Queen St., East, Archts.

Ont., Toronto—W. W. Pearse, Archt., 156 College St., will receive bids until June 15 for a 3 story Riverdale technical school including a steam heating, refrigerating, ventilation systems, etc., for the Bd. Educ. About $700,000.

CONTRACTS AWARDED

N. Y., New York—(Brooklyn Boro) The Third Street Constr. Co. Inc., c/o Shampan & Shampan, Archts. and Engrs., 50 Court St., will build two 6 story, 95 x 98 ft. apartment houses, one on 8th Ave. and 3rd St. and the other at Prospect Park West and 3rd St. About $500,000.

N. Y., New York—(Manhattan Boro) Isaac Haft, c/o Shampan & Shampan, Archts. and Engrs., 50 Court St., Brooklyn, will build a 6 story, 105 x 256 ft. apartment house on the Grand Concourse Blvd. About $750,000.

Tenn., Nashville—The Water Dept. has awarded the contract for improvements to the pumping station, to the Howard Eng. Co. of Nashville, at $217,330. Noted May 10.

O., Canton—G. D. Harter Bank Co., 113 Market St., has awarded the contract for a 12 story, 50 x 84 ft. bank and office building on the Public Square, to the Hunkin Conkey Constr. Co., Madison Ave., Cleveland. About $750,000. Noted May 2.

Ind., Evansville—Evansville College has awarded the contract for installing a steam heating system in the proposed 3 story, 70 x 174 ft. college administration building, to H. G. Newman Co.

Mich., Detroit—The Bd. Educ., 1354 Bway Ave., has awarded the contract for a 3 story, 151 x 332 ft. high school including steam heating and ventilating equipment on Fort St. and Waterman Ave. to F. G. Goddard, 2130 Franklin St., at $665,700. Noted Jan. 11.

Ia., Everly—The city has awarded the contract for a 40,000 gal tank on a 100 ft. tower, chlorination plant, pumping machinery and pump house, to the Pittsburgh-Des Moines Steel Co., 9th and Tuttle Sts., Des Moines at $7,780.

Minn., St. Paul—St. Joseph's Hospital c/o Mother Grace Aurelia, 9th and Exchange Sts., has awarded the contract for a 6 story, 45 x 200 ft. hospital including a steam heating system on Exchange St. between St. Peter and Main Sts., to Fred C. Norlander, 408 Metropolitan Bank Bldg., at $349,950.

Kan., Morgaoville—The city has awarded the contract for transmission line, to the Tri-State Electric Co., Rosedale, at $14,793. Noted April 26.

Kan., Osborne—The city has awarded the contract for engine and generator, to Busch Sulzer Bros. Diesel Eng. Co., 2d and Utah Sts., at $49,800.

Mo., New Haven—The city c/o John Greenstreet, City Clk., has awarded the contract for altering, improving and building additions to the electric power plant, to H. H. Washemeyer, Washington, Mo., and for engines and equipment, to Fairbanks & Co., 620 Market St., St. Louis.

Ont., Toronto—The Toronto Transportation Com., City Hall, has awarded the contract for electrical equipment for 40 cars, to the English Electric Co., c/o Transportation Comn., City Hall., for 50 cars, to the Canadian General Electric Co., 212 King St., West, for 50 cars, and air brake equipment for 140 cars, to the Canadian Westinghouse Co., Traders Bank Bldg. About $1,000,000.

Alaska, Ketchikan—The Ketchikan Cold Storage Co. has awarded the contract for a 5 story addition to its cold storage and ice plant, to the Warrack Constr. Co., Arcade Bldg., Seattle, Wash., at $85,000. Refrigerating equipment will be installed in same.

News of Opportunities—Pages 76 to 83

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